Upper Assiniboine River Basin Study

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Upper Assiniboine River Basin Study

Appendix B

Water Supply and Use Committee Report

August 2000

Executive Summary

The Water Supply and Use Committee of the Upper Assiniboine River Basin Study consisted of persons with expertise in a variety of disciplines with an interest in water management and representing Saskatchewan, Manitoba and Canada. The objectives of the Committee were to examine the water supply, water use, and determine the relationship between supply and use and how it impacts the current and future needs of the Basin. Consideration of water supply and use in this report is presented from a general planning perspective. The focus is on water quantity, and although groundwater quality is briefly noted, water quality is reported in greater detail by the Water Quality Committee in the appropriate appendix of the Study report. Detailed site specific analysis of water availability and quality is required when considering the potential of meeting the water needs of individual projects.

Surface water supplies were characterized by estimating the "pseudo-natural" flows for 23 watersheds for the period of record 1941 to1995. They were named in this manner because the flows were not adjusted for the historical effect of drainage. Groundwater supplies were characterized by gathering all of the previously interpreted geologic and hydrogeologic information incident to the surface drainage basin for a common presentation. Regional aquifer maps on a 1:50,000 scale were produced along with a total of 16 cross-sections.

Water uses were considered as either withdrawal or instream uses, and were estimated using a combination of recorded data, regulatory licence data, and simple analyses. Total present withdrawal use was estimated to be slightly over 60,000 dam^3/y. Reservoir evaporation was the largest use at approximately 35 percent of the estimated total use or 22,000 dam^3/y, the majority of that from Lake of the Prairies. Licenced allocations for wildlife conservation projects represent 31 percent or 19,000 dam^3/y and were considered a use category even though their effect on runoff volumes is expected to be small overall. Agricultural, municipal and industrial use represented 19 percent, 9 percent and 6 percent of the total use respectively. Future water use was projected to increase by approximately 5 percent and 7 percent by 2010 and 2020 respectively, given no significant large scale projects. Municipal use and agricultural use represent the largest increases in water use, with both expected to increase by about 25 percent. The increase in agricultural use is expected to be largely in the livestock sector.

A set of preliminary instream mean monthly flow estimates for fisheries were developed for the outlets of the 23 watersheds since a healthy aquatic life habitat requires a certain water supply. Other instream uses, such as recreation, were listed by water body.

A simple water management model was constructed to examine the state of surface water supply and the major water uses on a mean monthly basis for the 23 watersheds. The analysis reveals that at both the current and future level of water use surface water supply is generally sufficient, although it is less reliable in the headwaters of the Basin. As with all prairie areas it is subject to droughts. The preliminary analysis of instream flow needs suggests that water is available for aquatic ecosystems and offstream uses, but during periods of low flows there may be conflict.

Apportionment between Saskatchewan and Manitoba is not an issue in the Basin at the present time or in the foreseeable future. It was also determined that there was no reliable method to determine the effect of drainage or climate change on the supply and use relationship.

Groundwater management in the Basin is accomplished primarily through the provincial regulatory bodies. A detailed aquifer management plan is currently being developed for the Yorkton aquifer system. No further aquifer management plans are currently contemplated although additional developments may make them necessary.

General recommendations have been provided in the report. Surface water supplies should continue to be allocated subject to water availability and downstream demands for the foreseeable future. Measures should be taken to ensure the availability of adequate supplies of good quality water in all areas of the Basin. Instream flow needs should be an integral part of future water management and guidelines should be established with due consideration for other uses and reservoir operations. An increased effort is required in the area of groundwater management to better define and manage the resource. Finally, an enhanced water monitoring program should be implemented in the Basin to obtain data on actual surface water and groundwater usage and to ensure that all major uses are licenced and appropriately monitored.

Acknowledgements

The Water Supply and Use Technical Committee would like to thank the following individuals and groups for their assistance:

> Ron Woodvine, PFRA; Fred Martin, PFRA; Nolan Shaheen, Sask Water; Ron Bazuk, Sask Water; Harm Maathuis, Saskatchewan Research Council; Janet Campbell, Saskatchewan Research Council; Elaine Wheaton, Saskatchewan Research Council; Bob Betcher, Manitoba Conservation; Drainage and Flood Control Committee; Upper Assiniboine River Basin Study Management Committee; PFRA GIS Unit; Sask Water Drafting Unit; and the Local Watershed Committees.

Nomenclature and Definitions

AU	animal unit (1AU=1.5 feeder cattle = 3 sows = 20 weanling piglets = 6 feeder hogs)
dam^3	cubic decametre. (1 dam^3 = 1000 m^3)
GCM	General Circulation Model
IFN	instream flow needs - the amount and seasonal timing of flowing water in a stream required to sustain aquatic organisms and processes.
ILO	intensive livestock operation
lcd	litres per capita per day
l/d	litres per day
l/ha	litres per hectare
l/min	litres per minute
m^3/s	cubic metres per second
MAF	mean annual flow
MMF	mean monthly flow
mg/l	milligrams per litre
NTS	National Topographic Survey
PPWB	Prairie Provinces Water Board
R.M.	rural municipality
UARBS	Upper Assiniboine River Basin Study
WRMM	Water Resources Management Model
y	year

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1 Introduction

The Water Supply and Use Committee of the Upper Assiniboine River Basin Study is comprised of personnel from various fields of study with an interest in water management representing both Saskatchewan, Manitoba and Canada. The committee examined supply and use issues in the overall Upper Assiniboine River Basin to complement the work of other technical committees. Through public consultations, a number of issues were identified. These issues were reviewed and are addressed within the context of the objectives.

1.1 Objectives

Terms of Reference (Appendix I) and a work plan were developed to address the Study issues relating to water supply and use within available resources. The main objectives were:

- Examine the present and future water supply;
- Examine the present and future water use; and
- Examine the state of water supply vs. use for present and future needs.

Implicit in the objectives are factors which may affect the state of water supply and use in the Basin, e.g., the effect of drainage on water supply and the potential effect of global warming on both supply and use. The committee felt these items should be considered even if they cannot be easily quantified.

1.2 Scope of Work

As with any study, the available resources define the scope of the work, the level of data and technical analysis which can be pursued. The work of this committee relied primarily on existing data and in-kind contributions of technical expertise. Some resources were made available for basic groundwater mapping The committee used available data and standard methods of analysis on that data to examine the water supply and use.

The Upper Assiniboine River Basin is extensive in area, and the question of scale had to be addressed. Simply summarizing water supply and use on a Basin scale was considered less desirable than doing so on more discrete components such as watersheds or rural municipalities. Groundwater maps were prepared based on a 1:50,000 scale.

The consideration of water supply and use in this report is presented from a general planning perspective. The focus of this report is on water quantity, and although groundwater quality is briefly noted, water quality is reported in greater detail by the Water Quality Committee in the appropriate appendix of the Study report. Detailed site specific analysis of water availability and quality is required when considering the potential of meeting the water needs of individual projects.

2 Water Supply

2.1 Surface Water

For purposes of this Study, natural flows developed in previous studies were used as published, and recorded flows were used directly where Basin water uses were known to be small relative to the flows. Insufficient information was available to facilitate meaningful estimation of the magnitude of historic drainage volumes, so it was not possible to adjust the published natural or recorded flows for the effects of agricultural drainage. For that reason, the flows provided for water supply modelling purposes are termed "pseudo-natural flows." The pseudo-natural flows inherently reflect the net effect of historic land cover changes in the Basin which include bush clearing, agricultural drainage and cultivation practices. For convenience, the flows will be referred to simply as the "natural flows".

The surface water supply to the Basin was characterized by estimating the mean monthly "pseudo-natural flows" over the 55 year period 1941-1995 for 23 watersheds within the Upper Assiniboine River Basin shown in Figure 2.1 and listed in Table 2.1. The terms "watershed" and "aggregated spatial area (ASA)" are synonymous. Complete details on the calculation of the flows can be found in Appendix II.

Six stations for which monthly natural flows are available or could be readily estimated for the period 1941-95, were selected as key base stations. The 55-year period contains a representative sequence of critical low and high runoff years necessary for water supply modelling purposes. Adoption of this study period eliminates the need for extensive data estimation in earlier years when minimal recorded data was available. At the time of this work, hydrometric data more recent than 1995 were not yet available from Environment Canada. These six stations were subsequently used to estimate missing monthly natural flows at all 23 watersheds using effective drainage area and runoff ratios. The recorded monthly flows for the six key base stations are provided in Tables A-1 to A-6 in Appendix II.

Monthly natural flows were required for use in water supply simulations using the Water Resources Management Model (WRMM). Table 2.1 also provides a summary for each watershed of the effective and gross drainage areas, the median annual runoff over the study period, and the resulting median annual unit runoff.

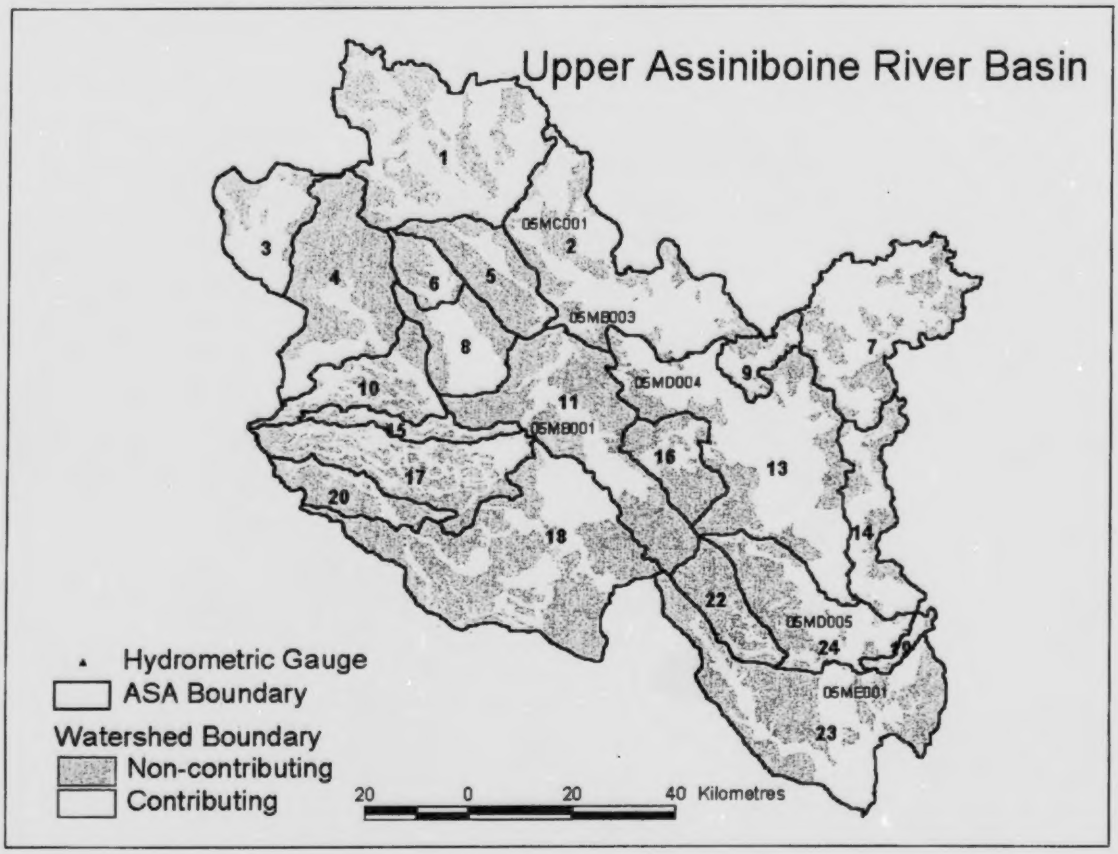
Figure 2.2 shows the mean annual natural flow volumes as calculated from the mean monthly natural flow volumes for the Upper Assiniboine River Basin outlet, i.e., the Assiniboine River above the confluence with the Qu'Appelle River. Periods of higher flows and droughts in the Basin are apparent in the figure. The flood of 1995 stands out with an annual volume in excess of 1.5 million dam^3. The mean and median annual natural volumes for the Basin are approximately 430,000 dam^3 and 314,000 dam^3 respectively.

Table 2.1 - Runoff Summary by Watershed

No.	Name	EDA[1] (km^2)	GDA[2] (km^2)	MAR[3] (dam^3)	MAUR[4] (mm)
1	Assiniboine River at Sturgis - 05MC001	1143.0	1926.6	64,746	56.6
2	Assiniboine River at Kamsack - 05MD004	1074.0	1697.8	53,160	49.5
3	Fishing Lake near Wadena - 05MB013	407.1	627.1	5871	14.4
4	Whitesand River near Sheho - 05MB004	270.1	1217.7	8260	30.6
5	Crooked Hill Creek near Canora - 05MB006	104.4	581.5	8993	86.1
6	Spirit Creek near Buchanan - 05MB007	103.6	260.1	6515	62.9
7	Shell River near Roblin - 05MD007	751.4	1329.2	71,012	94.5
8	Good Spirit Lake near Canora - 05MB010	301.0	564.6	18,927	62.9
9	Little Boggy Creek near Cote - 05MD006	126.7	254.8	11,276	89.0
10	Whitesand River at Theodore Reservoir	275.9	596.4	12,734	46.2
11	Whitesand River near Canora - 05MB003	348.6	1470.7	13,166	37.8
13	Lake of the Prairies near Shellmouth - 05MD009	1403.2	2144.7	56,305	40.1
14	Shell River near Inglis - 05MD005	375.0	665.9	25,418	67.8
15	Whitesand River above Yorkton Creek Confluence	138.9	253.3	5325	38.3
16	Stony Creek near Kamsack - 05MD010	115.8	456.1	5506	47.5
17	Cussed Creek at the Mouth	464.2	1033.3	18,124	39.0
18	Yorkton Creek near Ebenezer - 05MB001	410.0	2323.6	16,037	39.1
19	Conjuring Creek near Russell - 05ME005	59.3	88.5	2583	43.6
20	Willow Brook at Willowbrook - 05MB005	95.3	402.6	3360	35.3
22	Smith Creek near Marchwell - 05ME007	57.8	438.7	4025	69.6
23	Assiniboine River at Qu'Appelle River Confluence	755.0	1835.7	30,676	40.6
24	Assiniboine River near Russell - 05ME001	451.4	921.8	18,672	41.4
-	Upper Assiniboine River Basin	9 231.7	21,090.7	460,691	49.9

Note:
1. Effective drainage area for the ASA, judged as that area which contributes runoff to the main stream in a median (1:2) year, from the PFRA database.
2. Gross drainage area for the ASA, defined by the topographical watershed divide, from the Digital Elevation Model (DEM) developed for the Basin.
3. Median annual runoff from the 1941-95 monthly pseudo-natural flows estimated for each ASA.
4. Median annual unit runoff (dam^3/km^2 or mm) calculated as MAR/EDA.

Figure 2.1
Upper Assiniboine River Basin Watersheds


Upper Assiniboine River Basin
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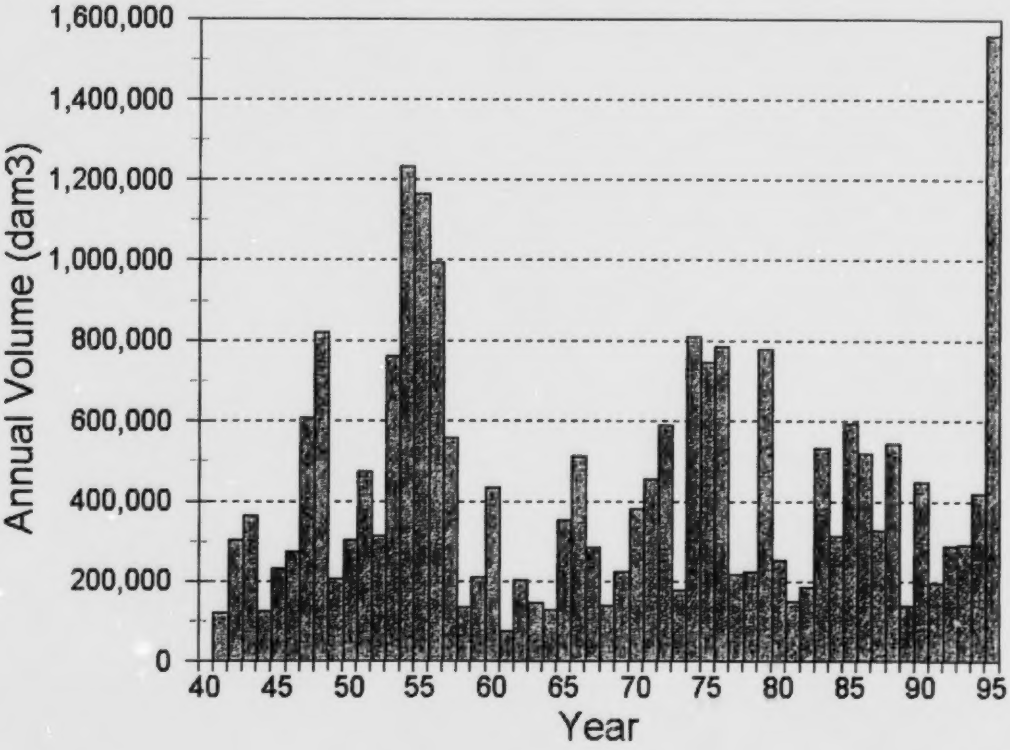
23
24
05MC001
05MB003
05MD004
05MB001
05MD005
05ME001
Hydrometric Gauge
ASA Boundary
Watershed Boundary
Non-contributing
Contributing
20
0
20
40
Kilometres

Figure 2.2
Assiniboine River above Qu'Appelle River Natural Volumes (1941-1995)



Surface Water Supply and Drainage

Drainage does not affect the water supply as much as it affects water availability. The effect of drainage is to remove stored water from the headwaters and move it down the Basin, where it becomes integrated into the downstream hydrology. The water is removed from numerous smaller storage bodies and is made available as channel flow and perhaps reservoir storage farther downstream.

Potential methods to estimate the historical effects of drainage on water availability were examined. Successful analysis would involve some method of removing the effects of drainage from the pseudo-natural flow arrays. Removing the effects of drainage from the historical records requires a methodology to estimate the historic change in wetland storage volume and the progression of that change over time for each watershed. New natural flow arrays adjusted for both use and drainage would then result.

The Drainage and Flood Control Committee of this Study examined the proposed methodologies and concluded that although it may be possible to develop some type of historical drainage flow arrays, the assumptions that would be made would render the results unreliable. The major problem is a general lack of historical information, particularly historic wetland storage data and information on the development of drainage over time. Since the drainage flows ultimately determined would not be technically defensible, the matter was not pursued.

2.2 Groundwater

Available groundwater supply, unlike surface water supply, cannot be directly measured. Therefore, defining the groundwater supply is much more involved and arduous than doing the same for surface water. For this Study, the groundwater basin can be considered as all the groundwater resources either partially or completely within the boundary of the Upper Assiniboine River Basin. The groundwater supply is then the yield of this groundwater basin. Freeze and Cherry (1979) define basin yield as the maximum rate of withdrawal that can be sustained by the complete hydrogeologic system without causing unacceptable changes to any other component of the hydrologic cycle in the basin.

Defining groundwater resources can be approached in a variety of ways, depending on the data and resources available. In very general terms, there are three basic types of resource definition:

1. Defining the groundwater supply for the entire groundwater basin (basin yield).

   The basin yield approach requires a clear understanding of the location, occurrence and characteristics of each individual aquifer in the groundwater basin. In addition, it requires an understanding of the overall hydrogeologic setting, including such things as the relationship between individual aquifers and the role of surface water. (An aquifer is defined here as a saturated geologic material which can supply water to a well in economic volumes). This level of knowledge requires extensive test drilling, production testing, monitoring and geologic/hydrogeologic analysis that is simply not practical to obtain for an area as large and geologically complex as the Upper Assiniboine River Basin. In addition to the technical and financial challenges of this approach, defining "acceptable impacts" and thus the maximum sustainable yield is very subjective. For example, a sustainable production from a surficial aquifer may also reduce the discharge of springs of a nearby creek. A consensus on whether or not that impact is acceptable may be difficult to achieve.

2. Defining the groundwater supply for individual aquifers (aquifer yield).

   The aquifer yield approach consists of determining the maximum sustainable yield for individual aquifers. The aquifer yield is represented by the maximum rate of withdrawal that can be sustained without causing an unacceptable decline in head in the aquifer. Estimating aquifer yields requires knowledge of the aquifer characteristics, hydrogeologic setting and hydraulic data including pump tests and generally long term production data with extensive monitoring of drawdown and recovery. Maximum sustainable yields are very difficult to define and will again vary depending on the interpretation of "acceptable impacts". This approach is also very data intensive and requires skilled interpretation of the data, and is again beyond the scope of this Study.

3. Defining the groundwater supply for individual wells (well yield).

Data are often inadequate to estimate safe aquifer yields. Outlining the groundwater resources of a specific area is then reduced to mapping the extent of aquifers, giving general hydraulic characteristics and well yields where available. This method of groundwater management is most common in the Upper Assiniboine River Basin. Well yield is defined as the maximum pumping rate that can be sustained without causing an unacceptable decline in head in the aquifer or a nearby well.

Monitoring to ensure the withdrawals are sustainable is important. Individual well yields tend to be based on safe entrance velocities and shorter term pump tests. Analysis of these tests is based on the assumption that the aquifer is of infinite extent and thus does not account for any physical limitations in the larger hydrogeological system.

The complete characterization of groundwater resources, even for a simple system, requires significant amounts of data and skilled data interpretation. For an area as large and hydrogeologically complex as the Upper Assiniboine River Basin, a complete characterization would require great amounts of data and equal amounts of skilled data interpretation. The required resources are far beyond the scope of this Study. The approach used herein to describe the groundwater resources of the Upper Assiniboine River Basin was to show the mapped aquifers and where possible to give an indication of well yields and general water quality.

2.2.1 Scope and Methodology of Groundwater Review

The groundwater resource review for the area coincident with the Upper Assiniboine River Basin is published in a supplementary report entitled *Geology and Groundwater Resources in the Upper Assiniboine River Basin* (Maathuis *et al.* 1999). The scope of the review was to summarize the geology and hydrogeology frameworks of the Basin relevant to the potable groundwater resources, and to summarize the occurrence and characteristics of the groundwater on a regional scale. That report shows the previously mapped aquifers and briefly presents what has been interpreted to be the hydraulic and water quality nature of the each aquifer where it is known. The information presented in this chapter has been extracted from the companion report, therefore each specific item is not referenced.

The resources available for the Study limited the estimate of groundwater supply to the compilation of previous interpretations of quality geologic and hydrogeologic data on a regional scale. The compilation and verification of new data, in addition to the reinterpretation of geological maps and cross-sections was beyond the scope of this Study.

The hydrogeological review is based on the mapping for various portions of six NTS mapsheet areas that encompass the Basin, all of which include at least portions of Saskatchewan, while three include portions of Manitoba. In Saskatchewan, the ability to manage groundwater prior to the 1960s was limited because of limited data. Beginning in the early 1960s and continuing on until 1980, Saskatchewan Research Council was assigned the task of developing a better understanding of the resource and undertook an exploration program to map and characterize groundwater resources. This work resulted in a basic understanding of groundwater resources in the province and allowed preparation of the first series of groundwater maps. Since 1980, exploration has been done on a need to know basis by proponents of projects. This means that new information has been compiled on a site specific basis. Data collection has continued, however, and the original groundwater map sheets have each been revised once during the 1990s. Saskatchewan now has a second generation of groundwater maps which map bedrock aquifers, Empress aquifers, and aquifers in Quaternary sediments on a regional scale.

In Manitoba, a program of regional hydrogeologic mapping based on 1:250,000 NTS map sheets within the southern and central agricultural parts of the province was initiated in the mid-1970s. Test drilling and water sampling within each map sheet unit was undertaken followed by production of a series of maps. Studies were completed for all or part of 11 map sheet units by 1987. This was followed by the updating of two of the map sheet studies. The earlier reports consisted of a series of maps presenting drift thickness, bedrock surface topography, bedrock and surficial geology, a series of cross-sections and a compilation of groundwater analyses. Later reports also included maps showing the potentiometric surface of major aquifers, the generalized distribution of aquifers and the distribution of groundwater quality in the major aquifers. Extensive notes were also provided on many of the maps. This program has been in abeyance since 1993.

In addition to the regional 1:250,000 map sheet studies, detailed evaluations have also been undertaken on a number of major aquifers in Manitoba that have been developed for water supply or which are primary sources of community water supply. These studies have included the establishment of extensive water level monitoring networks and, in some cases, water quality networks. Monitoring and supplementary studies continue for these aquifers.

The geologic setting or parts thereof are based on various works published from 1966 to 1999, without accounting for any new information which was received after the publication date. As a result, the existing maps and cross-sections for Saskatchewan and Manitoba used in this Study include bedrock geology and topography for both provinces and the extent of aquifers in Quaternary sediments for Saskatchewan. Complete details on the types and origin of data can be found in the supplementary report (Maathuis *et al.* 1999).

The supplementary report provides a basic discussion of types of aquifers, aquifer maps, water quality information and potential well yield where known. The report provides the basic geological setting and groundwater resources on a regional scale, and is for general information only, as the nature of deposits is exceedingly complex and variable. Assessment of the water supply potential for any use requires a site specific interpretation of all available data and possibly exploration, test well installation and pump testing, water level monitoring and water sampling and quality analysis.

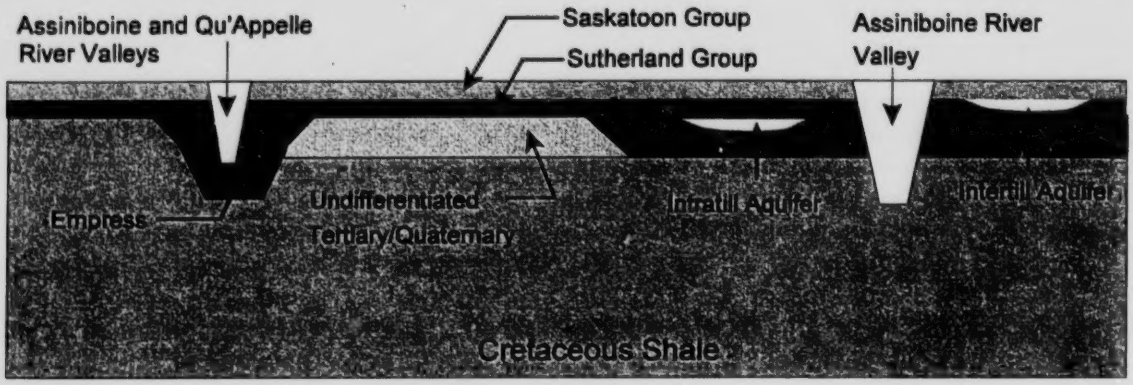
2.2.2 Results

The result of the groundwater review is a presentation of the geological history of the Basin area, a review of the basic groundwater resources of the area, maps of known regional aquifers based on a 1:50,000 scale and a total of 16 cross-sections throughout the Basin to illustrate the geologic and hydrostratigraphic setting of the Basin area. Groundwater resources are discussed and mapped for the sediments above the base of groundwater exploration corresponding in general to those sediments of the Late Cretaceous Period to the present time. It is important to note that the aquifer maps are based on limited data and on geological interpretation, therefore the boundaries are not exact and actual site specific conditions may not reflect the maps. Assessment of groundwater resources at a specific site requires an interpretation of all available site specific and regional data and including possible site exploration.

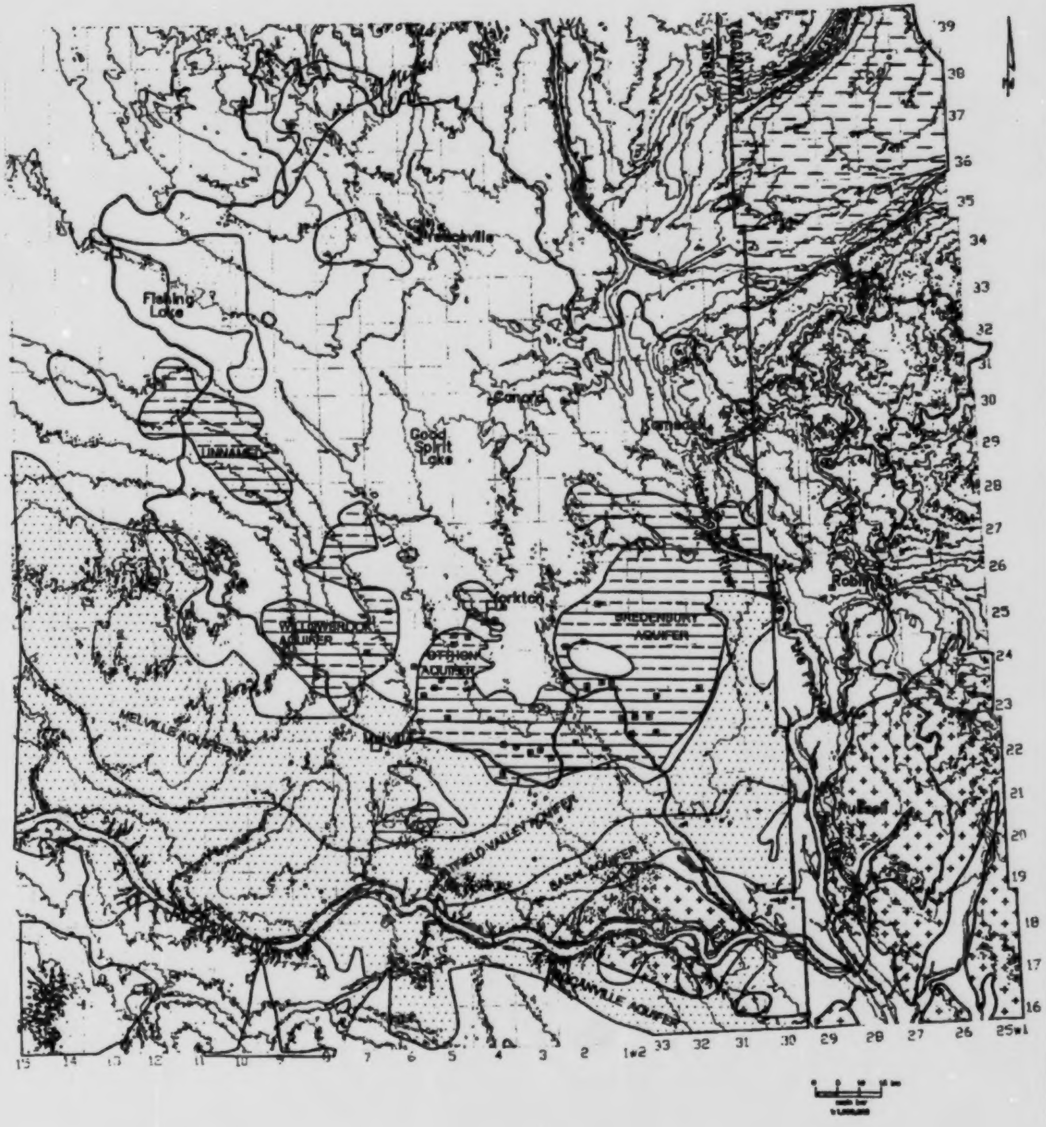
The results of the mapping can be considered in two main divisions, bedrock aquifers of pre-Quaternary age and aquifers of Quaternary age deposits within the glacial drift. The bedrock stratigraphy used in both Saskatchewan and Manitoba was harmonized and aquifers were mapped for the entire Basin area. Although a stratigraphic framework of Quaternary deposits has been developed in Manitoba, little has been done in terms of regional mapping of drift units. In Saskatchewan, detailed Quaternary stratigraphy has been developed and the major groups can be differentiated in much of the area, and where it is not, the drift was simply considered an undifferentiated unit. Since it was beyond the scope of the Study to correlate the Saskatchewan and Manitoba stratigraphy, the cross-sections were extended into Manitoba using the Saskatchewan stratigraphic setting.

Figure 2.3 shows a schematic cross-section of the Basin geology in a greatly simplified form to demonstrate the vertical profile according to the Saskatchewan stratigraphic setting from the Late Cretaceous Period to the present. The entire Basin is underlain by Cretaceous shales which form the bedrock surface in most of the area. In the few areas where remnants of undifferentiated Tertiary/Quaternary sediments remain, they form the bedrock surface. Based on the Saskatchewan stratigraphy, glacial drift in the Basin can be subdivided into three groups which are the Empress, Sutherland and Saskatoon groups in ascending order. Prior to the first glaciation, the Hatfield Valley was formed by fluvial erosion and deposition of Empress Group sediments. The Quaternary Period included both deposition and erosion, as several continental glaciations occurred which had a profound effect on the landscape. Till units of the Sutherland and Saskatoon groups were deposited during successive glacial stages. Stratified sediments, including the sands and silts forming many of the aquifers in the Basin, were deposited during intraglacial, interglacial, and proglacial stages.

Figure 2.3
Schematic Geologic Cross-section


Assiniboine and Qu'Appelle River Valleys
Saskatoon Group
Sutherland Group
Assiniboine River Valley
Empress
Undifferentiated Tertiary/Quaternary
Intratill Aquifer
Intertill Aquifer
Cretaceous Shale

The aquifers have been grouped and shown based on their occurrence in the vertical profile. Regional aquifer maps are provided in Figures 2.4 to 2.8. Drift aquifers are not shown in the Manitoba portion of the Basin as they have not been mapped. Table 2.2 summarizes the occurrence and some general but known properties of the major aquifers in each category. The maps show only the regional aquifers which have been delineated to date based on information made available. It is likely that there are other regional aquifers which have yet to be mapped, and there are certainly many smaller aquifers which do not appear on the maps but are capable of supplying users with significant amounts, individually or in communities. The lack of units shown illustrates that much work remains to be done in both mapping and providing specific aquifer characteristics. Chapter 5.2 contains more discussion on groundwater, including certain specific areas of interest (such as the Yorkton and Canora areas), specific surface water/groundwater interactions, and groundwater use regulation.


Flaking Lake
Preeceville
Good Spirit Lake
Canora
Kamsack
Yorkton
Roblin
Russell
Melville
UNNAMED
WILLOWBROOK AQUIFER
OTTHON AQUIFER
BREDENBURY AQUIFER
MELVILLE AQUIFER
HATFIELD VALLEY AQUIFER
BASIN AQUIFER
MANNVILLE AQUIFER
39
38
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26
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22
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25w1
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1w2
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26
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Figure 2.4

Bedrock aquifers and aquifers formed by the Empress Group in the Upper Assiniboine River basin area.

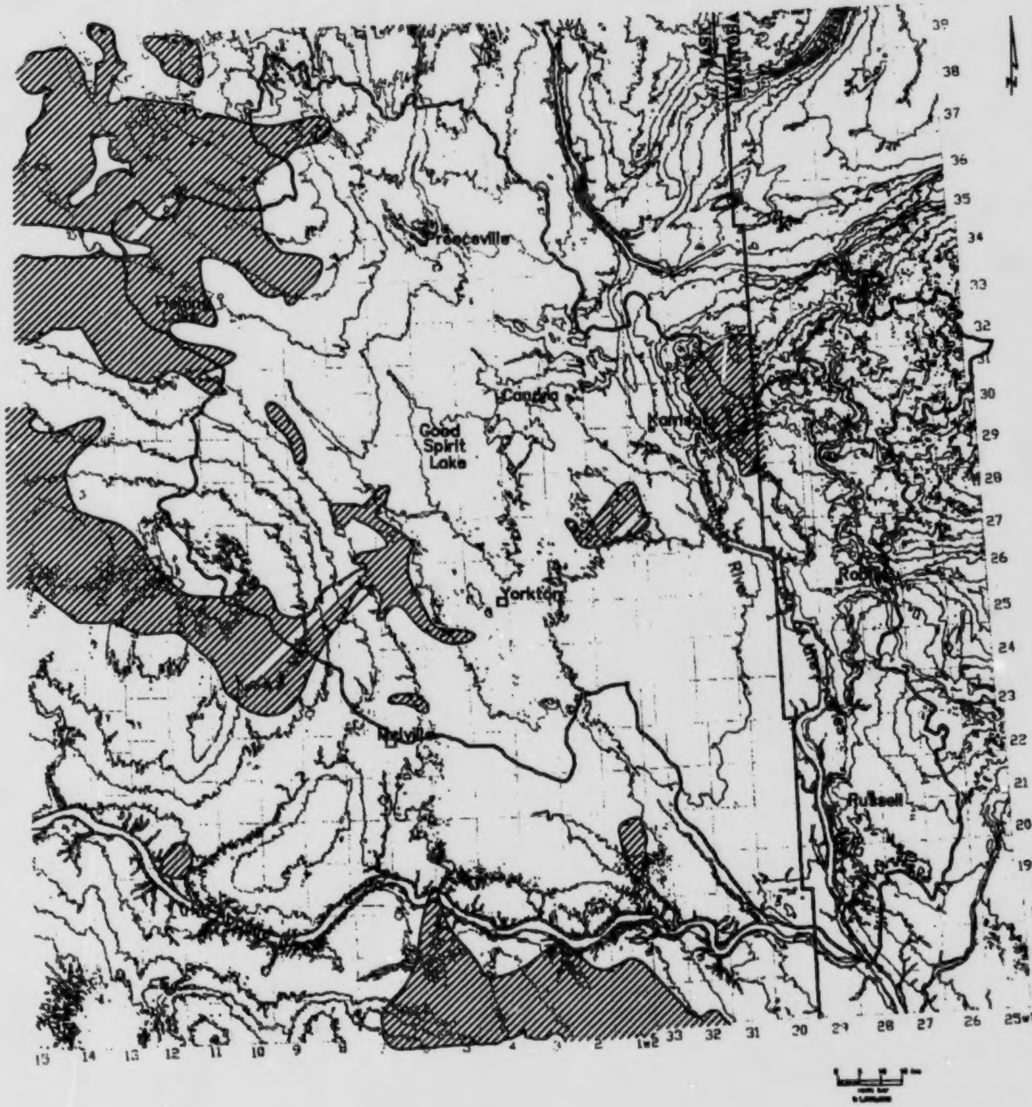
LEGEND

- ~ - Upper Assiniboine River drainage basin
- ▨ - Mannville aquifer
- ☰ - undifferentiated Tertiary-Quaternary aquifers
- ☐ - Empress Group aquifers
- ⊠ - Odanah Member
- ~ - Hatfield Valley

- ■ - water quality data for Bredenbury aquifer
- • - water quality data for Hatfield Valley aquifer

Accompanies SRC report: H.Maathuis, J.Campbell, J.Fahlman, 1999. Geology and Groundwater Resources in the Upper Assiniboine River Basin. Saskatchewan Research Council, Publication 10421-1E99.

cad file: fig1021.dwg
March 2000


SASK
MANITOBA
Preeceville
Canora
Good Spirit Lake
Kamsack
Yorkton
Melville
Russell
River
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
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23
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1w2
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26
25w1

Figure 2.5

Extent of aquifers within the Sutherland Group in the Upper Assiniboine River basin area.

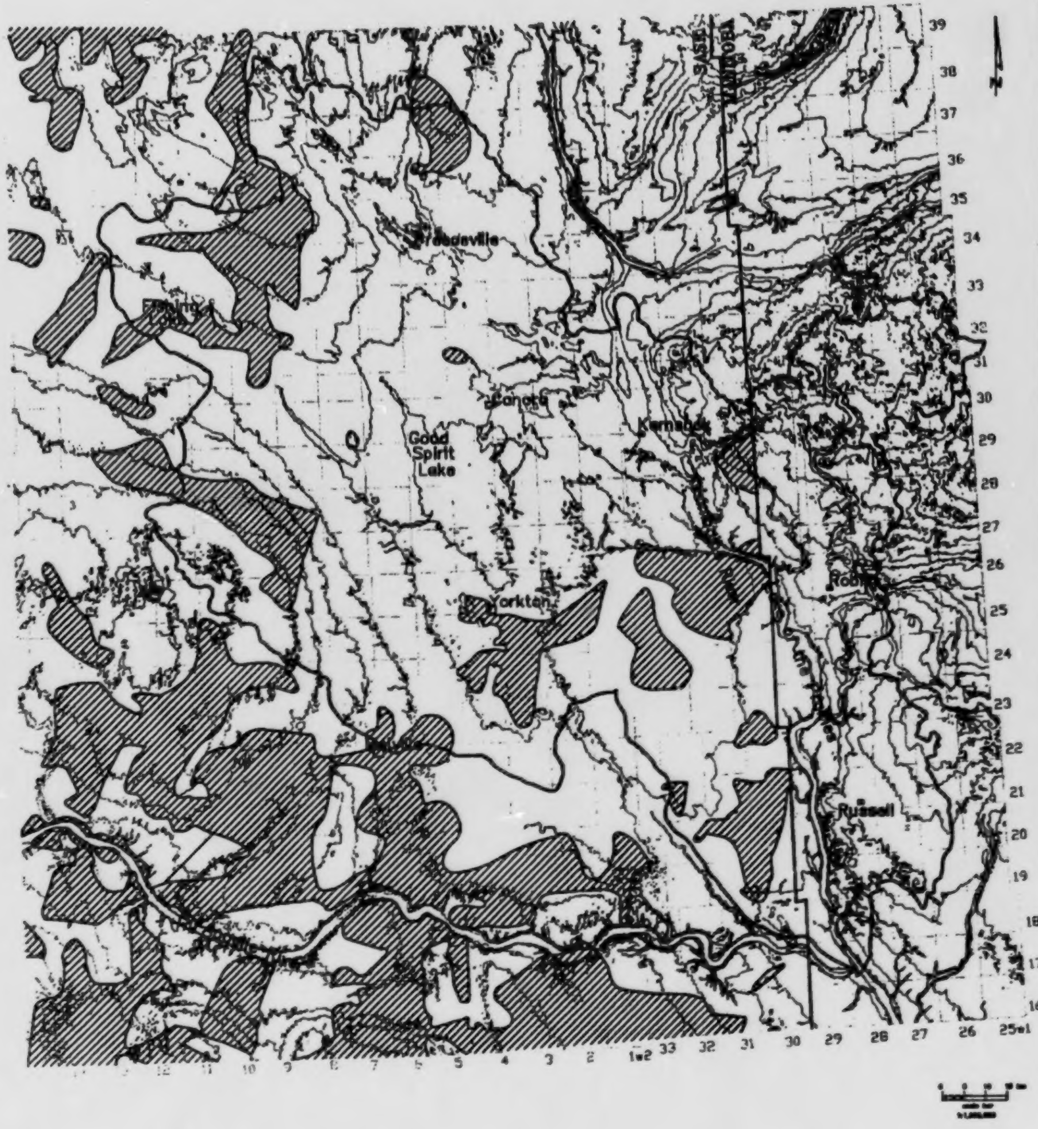
LEGEND

~ – Upper Assiniboine River drainage basin

▨ – Sutherland Group aquifers

Accompanies SRC report: H.Maathuis, J.Campbell, J.Fahlman,
1999, Geology and Groundwater Resources
in the Upper Assiniboine River Basin. Saskatchewan
Research Council, Publication 10421-1E99.

cad file: fg1611.dwg
March 2000


Preeceville
Canora
Kamsack
Good Spirit Lake
Yorkton
Roblin
Russell
SASK.
MANITOBA
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25w1

Figure 2.6

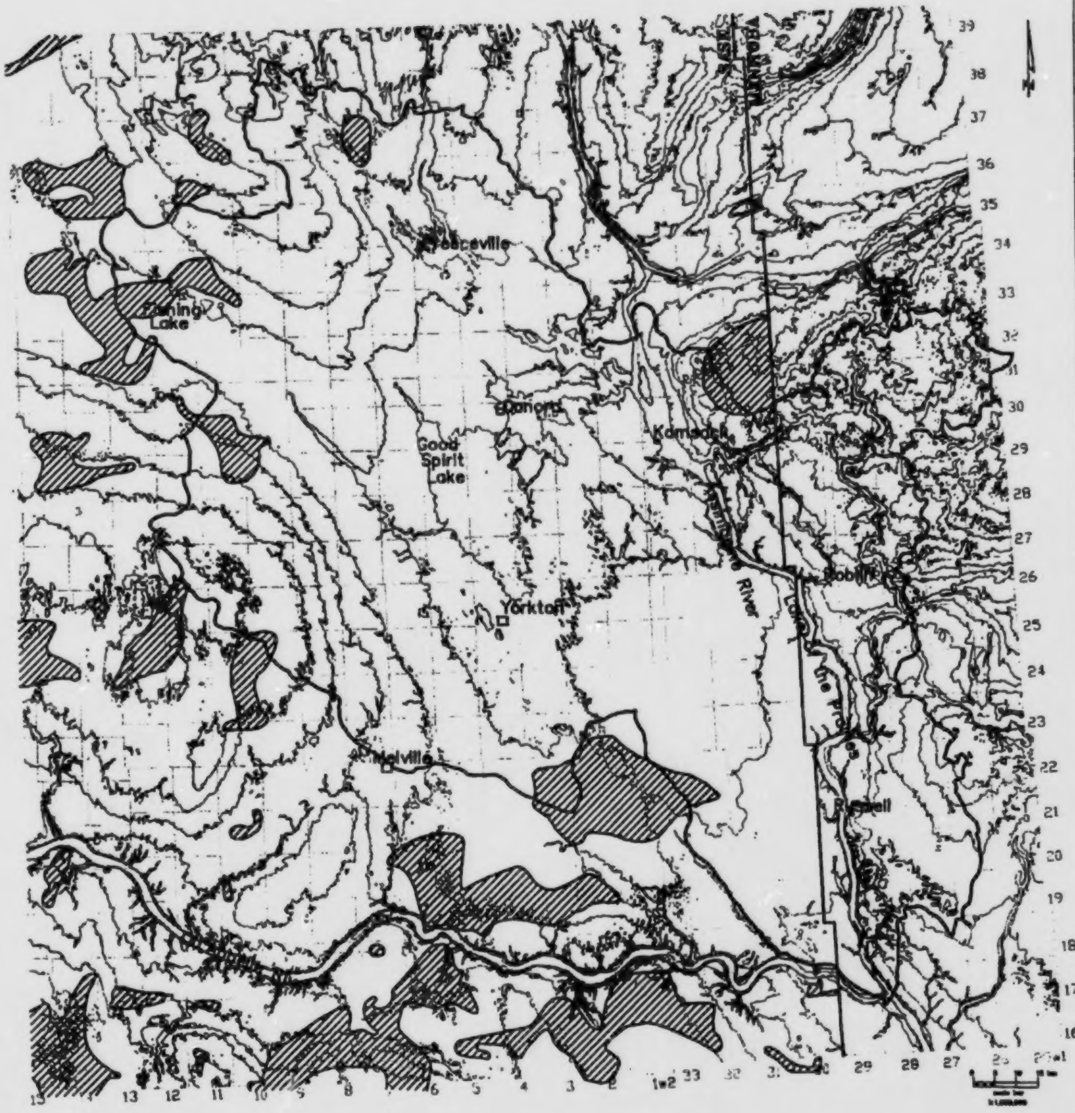
Extent of aquifers between the Sutherland and Saskatoon groups (interglacial aquifer) in the Upper Assiniboine River basin area.

LEGEND

- ~ – Upper Assiniboine River drainage basin
- ▨ – Intertill aquifer

Accompanies SRC report: H.Maathuis, J.Campbell, J.Fahlman, 1999. Geology and Groundwater Resources in the Upper Assiniboine River Basin. Saskatchewan Research Council, Publication 10420-1E99.

[illegible] file: [illegible]
March 2000



MANITOBA
SASK.
Preeceville
Fishing Lake
Canora
Good Spirit Lake
Kamsack
Assiniboine River
Roblin
Yorkton
Lake of the Prairies
Melville
Russell
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Figure 2.7

Extent of aquifers within the Saskatoon Group in the Upper Assiniboine River basin area.

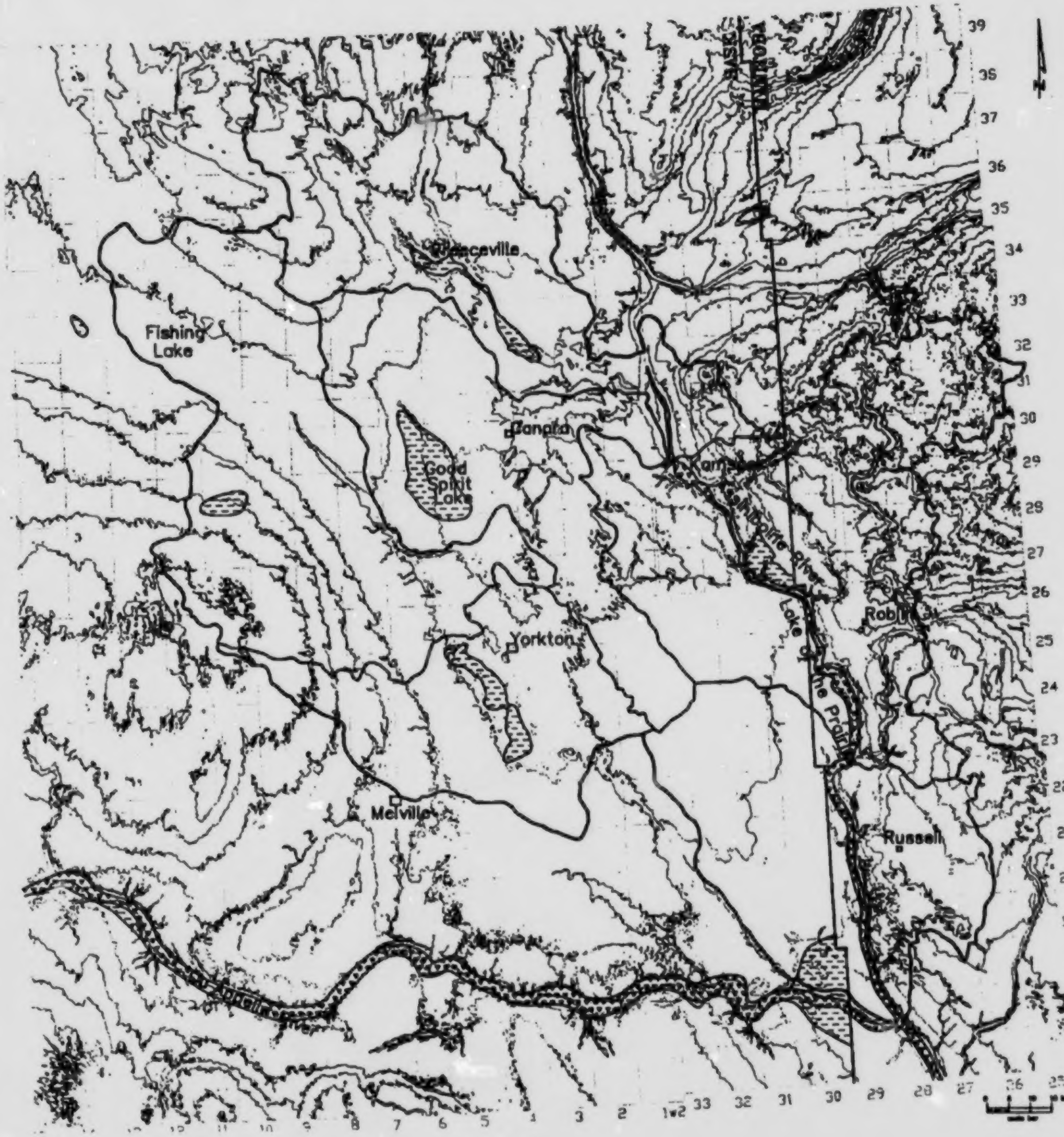
LEGEND

~ - Upper Assiniboine River drainage basin

▨ - Saskatoon Group aquifers

Accompanies SRC report: H.Maathuis, J.Campbell, J.Fehrman,
1999. Geology and Groundwater Resources
in the Upper Assiniboine River Basin. Saskatchewan
Research Council, Publication 10421-1E99.

cad file: fig13611.dwg
March 2000


Fishing Lake
Wadena
Good Spirit Lake
Canora
Kamsack
Assiniboine River
Yorkton
Melville
Lake of the Prairies
Roblin
Russell
SASK.
MANITOBA
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1w2
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25w1

Figure 2.8

Extent of surficial and alluvial aquifers
in the Upper Assinboine River basin area

LEGEND

〰 - Upper Assiniboine River drainage basin

▨ - surficial aquifer

V V - alluvial aquifer

Accompanies SRC report: H.Maathuis, J.Campbell, J.Fahlman,
1999, Geology and Groundwater Resources
in the Upper Assiniboine River Basin, Saskatchewan
Research Council, Publication 10421-1E99.

[illegible]
March [illegible]

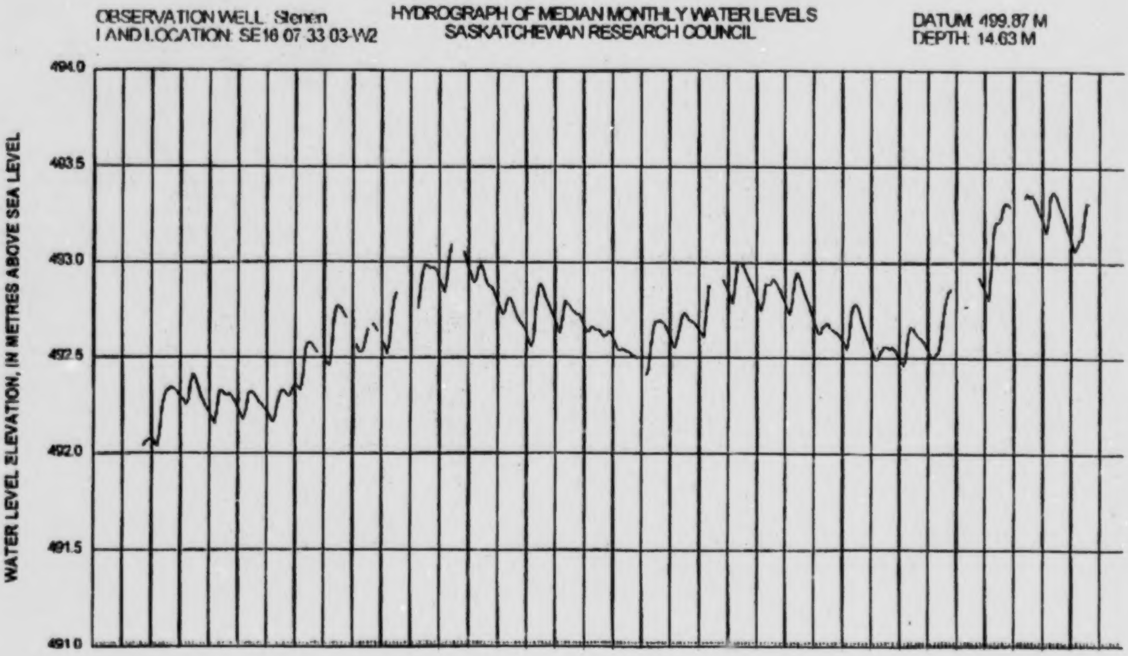
The water quality ranges applied to specific formations are based on data from a variety of sources but have been used only when the existing literature has indicated which formation the analysis represents. The data in Table 2.2 summarize the data available in the supplementary report, and show that water quality in all formations is extremely variable.

Table 2.2 - Summary of Mapped Regional Aquifers

Type of Aquifer		**Major Aquifers**	**Occurrence in UARB**	**Specifics / Well Yields**	**General Water Quality (sum of ion, mg/l)**
Quaternary	Surficial / Alluvial	Numerous	Various locations		
	Drift Aquifers	Numerous	Various locations		
	Empress Group	Hatfield Valley	Southeast corner	0-80 m thick	variable 1000 to >4000
		Basal	Extreme southeast	20 m thick	
		Melville	Extreme south	30 m thick	
		Others	Various locations		
Bedrock Aquifers	Undifferentiated Tertiary / Quaternary	Bredenbury	Southern portion		variable 800 to >3000
		Otton	Southern portion		
		Willowbrook	Southern portion		
	Cretaceous silts and clays	Odanah	Extreme southeast corner	up tol l/min MB	variable 500-2800
		Mannville	Used only in extreme northeast underlies most of Study area	40-150 m thick up to8 l/min MB	variable

Water level fluctuations which are characteristic of the natural behaviour of groundwater levels within the Study area are reflected in the data from observation well SRC Stenen shown in Figure 2.9. Groundwater levels naturally rise and fall during different periods due to the overall hydrologic conditions. Levels have generally been rising since the early 1990s.

Figure 2.9
Monitoring Well SRC Stenen Hydrograph



The shortcomings of aquifer mapping are obvious in light of the fact that there are large areas where no aquifers are shown but yet fully functional wells are known to exist. These aquifers are not mapped due to any one or combination of the following reasons:

- There is simply insufficient data of an acceptable quality available to map the aquifer;
- The data available may be of sufficient quality and quantity, however the resources to do the mapping are not available; and
- The aquifer is small in scale and cannot be mapped (i.e., not regional).

Mapping of all aquifers would require significant data collection, verification, and interpretation. A change in map scale may also be required, depending on the size of aquifers to be shown.

3 Water Use

3.1 Scope of Study and Classification of Water Use

Present and possible future water uses in the Basin were examined to assess the state of supply vs. use in the Basin. The scope of the current Study was to estimate present uses through existing data, the limits of which are discussed in each chapter. New data were not gathered and the existing data were not verified. Future use estimates were based on analytical techniques. Future use estimates for other sectors were based on general knowledge and reasoning.

There are numerous ways to categorize water use, with variations based on the type of supply, the sector of use and whether or not the use can be easily quantified. The approach taken in this Study divides water use into two main categories: withdrawal uses and instream uses. The distinction is based on whether or not the use withdraws water from the source and is then unavailable for other uses, at least for a period of time. The two main categories are then further sorted by the sector of use. The water use categories are as follows:

Withdrawal Uses

1. Municipal - residential, commercial, public and institutional uses supplied by an urban distribution system;
2. Industrial - major industrial uses with independent supply systems, mainly for mineral extraction, petroleum, and food processing;
3. Agricultural - includes rural domestic use, livestock, crop spraying, irrigation, and dugout evaporation;
4. Reservoir Evaporation - the incremental increase in evaporation due to the increased surface area of an artificially enlarged water body; and
5. Wildlife Conservation - similar to reservoir evaporation, but specific to wildlife conservation projects (mainly Ducks Unlimited projects).

Instream Uses

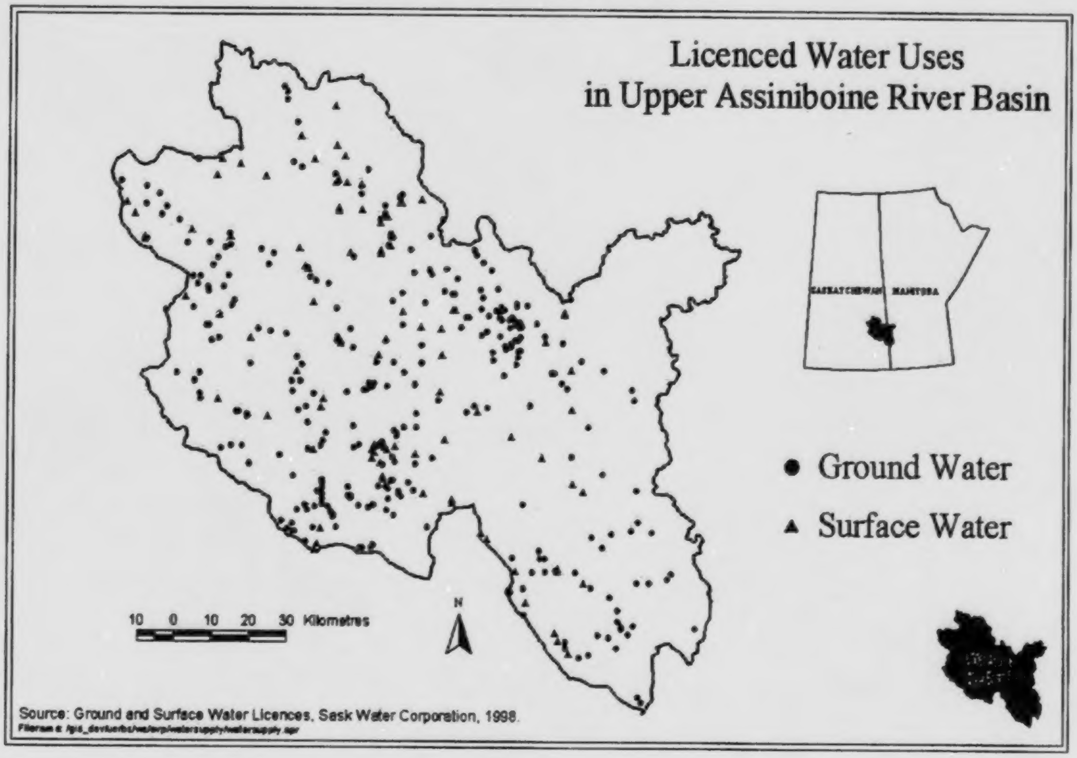
1. Instream Flows - the amount and timing of discharge in a stream, a critical component of habitat for fish and other aquatic life in streams; and
2. Recreational Uses - various recreational activities which require water or are enhanced by the presence of water bodies, including swimming, boating, camping, sportfishing, eco-tourism, etc.

The above classification of water use facilitates a discussion of how water is used, how much water is used, and how that use may change in the future. Present withdrawal uses are provided in the following chapter (3.2), while a discussion of future withdrawal estimates follows in Chapter 3.3. Chapter 3.4 discusses instream uses.

3.2 Present Withdrawal Uses

Present withdrawal uses were estimated using either recorded data if available, water licence data (allocations) or statistical data with appropriate analysis. All non-domestic uses require regulatory approval. Figure 3.1 shows the licenced water users in the Basin and provides an indication of how uses are distributed geographically.

Figure 3.1
Licenced Water Use Locations


Licenced Water Uses
in Upper Assiniboine River Basin
SASKATCHEWAN
MANITOBA
● Ground Water
▲ Surface Water
10 0 10 20 30 Kilometres
N

Source: Ground and Surface Water Licences, Sask Water Corporation, 1998.

3.2.1 Municipal Water Use

Municipal water uses include those serviced by distribution systems in cities, towns, villages and hamlets. Since these water systems are regulated, recorded water uses are available. Commercial and industrial uses serviced by municipal lines are considered municipal uses. Rural farm distribution systems have not been considered municipal water uses in this Study.

Water use records are available in both Saskatchewan and Manitoba for varying periods depending on the town or city. Tables 3.1 and 3.2 list the communities and their gross water uses (i.e., do not account for effluent releases) by source for both 1998 and the average for the five year period from 1994 to 1998 inclusive for Saskatchewan and Manitoba respectively.

Table 3.1 - Current Municipal Water Use - Saskatchewan

Community	Source	Water Use (dam^3/y)	
		1998	5Yr. Ave. (1994-1998)
Badgerdale (Cote)	SW	31*	31*
Bredenbury	GW	46.3	47.3
Buchanan	GW	61.2*	61.2*
Calder	GW	13.3	9.8
Canora	SW	280	278
Churchbridge	GW	107*	107.1
Ebenezer	GW/SW	16.7	17.5
Endeavour	GW	66.7	63.0*
Fenwood	GW/SW	3.4	3.7
Gerald	GW	16.8	17.2
Hyas	GW	24.7	21.2
Insinger	GW	0.7	0.8
Invermay	GW	43.2	39.4
Jedburgh	GW	1.9	1.7
Kamsack	SW	315	279
Ketchen	SW	1.6*	1.6*
Kuroki	SW	8.9	9.8
Langenburg	GW	153	155
Lintlaw	GW	45.8	43.7
MacNutt	GW	12.2	12.7
Margo	GW	26	27.6
Melville	GW/SW	643	633
Mikado	SW	5.8	5.3
Preeceville	GW	206	222
Rama	SW	9	8.7
Rhein	GW	18	22.5
Saltcoats	GW	102	92.5
Sheho	GW/SW	26.8	30.3
Springside	GW	63	69.4
Spy Hill	GW	39.9	37.5
Stenen	GW	16.6	15.9
Sturgis	GW	134	145
Tadmore	GW	2.2	2.8
Theodore	GW	123	97.3
Togo	GW	24.9	23.1
Veregin	GW	9.9	8.2
White Spruce	GW	12	12
Willowbrook	GW	6*	6*
Wroxton	GW	7.5	6.3
Yorkton	GW	2114	2160
Hamlets[1]	GW	55*	55*
Parks Facilities[2]	GW	41*	41*
SASKATCHEWAN TOTALS		4935	4927

* - estimated

[1] - Hamlets include: Amsterdam, Crystal Lake, Hazel Dell, Kylemore, Okla, Parkerview, Runnymeade, Spiritwood Acres, Tuffnell

[2] - based on allocated volumes and include: Foam Lake Campsite, Good Spirit Lake Provincial Park, York Lake Regional Park

Table 3.2 - Current Municipal Water Use - Manitoba

	Community	Source	Water Use (dam^3/y)	
			1998	5Yr. Ave. (1994-1998)
1	Angusville	GW	13.5	10.2
2	Binscarth	GW	47.9	44.5
3	Inglis	GW	12.4	12.9
4	Roblin	GW	335	255
5	Russell	GW	181	180
	MANITOBA TOTALS		590	503

In addition to the recorded municipal uses, there are a number of parks with licenced allocations used primarily for parks facilities, campgrounds, etc. The water use for these entities is classified as municipal for this Study. The estimated water use is equal to the allocation as there were no use records available.

Table 3.3 summarizes the data by province and source for the Basin. Total Basin use in 1998 is estimated to be approximately 5300 dam^3, of which roughly 80 percent is groundwater.

Table 3.3 - Summary of Current Municipal Water Use

	Saskatchewan		Manitoba		Basin Totals	
	Number	1998 Use (dam^3/y)	Number	1998 Use (dam^3/y)	Number	1998 Use (dam^3/y)
Surface Water	7	620	0	0	7	620
Groundwater	39	3558	5	590	44	4148
Shared*	4	690	0	0	4	690
Totals	50	4869	5	590	55	5458

* - approximately 50% groundwater, 50% surface water

3.2.2 Industrial Water Use

Uses classified as industrial are generally those for commercial or industrial purposes and having supplies independent of municipal systems. There are a total of nine users in the Basin considered to be in the industrial category involved largely in mineral extraction, petroleum, food production and food processing. One recreational industry use, the Asessippi ski hill, has been included. Table 3.4 lists the users and their allocated annual uses. Allocation details are provided in Appendix III.

The amount of recorded data for the industrial users is limited. The largest user is the Potash Corporation of Saskatchewan mine near Rocanville, which has wells located just inside the drainage boundary. Uses as reported to the regulatory body are shown in Table 3.4. The next two largest users, according to allocation data, are Transgas and Dome Petroleum. These allocations were granted for cavern washing, a one time use for construction of gas storage facilities and are no longer needed unless further storage is required. It is assumed this water is no longer actually used, however field verification is required to support this statement.

Table 3.4 - Summary of Industrial Water Use

User	Province	Source	Allocation (dam^3/y)	Average Actual Use 1994-1998 (dam^3/y)	Purpose
Big Sky Pork	SK	GW	1	N/A	Food Production
Canamera Foods	MB	SW	74	88	Food Processing
Crescent Creek Poultry	SK	GW	4.9	N/A	Food Production
Dairy Producers	SK	GW	31.9	N/A	Food Processing
Dome Petroleum	SK	GW	1476	N/A - assumed inactive	Petroleum
F+B Feedlot	SK	GW	49.2	N/A	Food Production
Potash Corp.of Sask.	SK	GW	1382	990	Mineral Extraction
Ski Asessippi	MB	SW	69.08	N/A	Recreation
Transgas	SK	GW	463	N/A - assumed inactive	Petroleum
Total Use			3554		

The two industrial uses in Manitoba are for food production and a ski hill. Recorded water use data are available for Canamera Foods and are also shown in Table 3.4. The Asessippi Ski Hill is a very recent water use and recorded data are not available yet. The remainder of the industrial users are relatively small and water use data are not pursued.

There are inaccuracies inherent when basing water use estimates on allocated volumes rather than recorded volumes. First, it is not known if the data are current. Second, allocations granted may be in error due to ensuring adequate supply for a user by allowing for future expansion of the business. Third, the water may be allocated for temporary uses and does not reflect the ongoing continued uses. Actual water uses are normally less than allocated volumes, however allocated data are often the only data available and thus are used in this Study. Field verification of allocated volumes with actual use is required to provide accurate industrial water use estimates, however such a procedure is beyond the scope of this Study.

3.2.3 Agricultural Water Use

Water use for agricultural purposes was divided into five categories; rural domestic, livestock, crop spraying, irrigation and evaporative losses from dugouts.

3.2.3.1 Rural Domestic

Rural domestic water use is considered to be water supplied to farm residences by dugout, well, water hauling or rural pipeline. Some water use may be accounted for in the municipal water estimates, however this double counting of use is not considered significant.

Water use projections were based on estimated rural population multiplied by 270 l/d which is commonly used for the design of residential complexes. Rural populations were estimated from the 1996 Canada Census data, which provide populations by rural municipality (R.M.). Each R.M.'s population in the Basin was prorated based on the percentage of R.M. area in the Basin. Table 3.5 provides complete information for the 1996 number of farms and population in each R.M. found in the Basin. Based on a per capita consumption rate of 270 l/d, the total water use by rural households would be 1763 dam^3/y.

Table 3.5 - Prorated Number of Farms and Population in the Upper Assiniboine River Basin

Rural Municipality	Total Number of Farms	Pop.	% of R.M. in Basin	Prorated Number of Farms	Prorated Pop.
Spy Hill #152	129	496	41	53	203
Langenburg #181	199	768	76	151	584
Churchbridge #211	266	876	97	258	850
Saltcoats #213	226	886	65	147	576
Cana #214	263	1014	76	200	771
Stanley #215	252	696	22	55	153
Calder #241	191	542	100	191	542
Wallace #243	263	1044	100	263	1044
Orkney #244	299	1810	100	299	1810
Garry #245	204	565	96	196	542
Ituna Bon Accord #246	223	559	28	62	157
Cote #271	187	687	96	180	660
Sliding Hills #273	223	650	100	223	650
Good Lake #274	224	722	100	224	722
Insinger #275	217	567	100	217	567
Foam Lake #276	337	838	45	152	377
St Philips #301	139	331	33	46	109
Keys #303	162	448	82	133	367
Buchanan #304	194	546	100	194	546
Invermay #305	192	514	100	192	514
Clayton #333	315	886	21	66	186
Preeceville #334	372	1202	80	298	962
Hazel Dell #335	235	796	79	186	629
Sasman #336	273	1031	63	172	650
SASKATCHEWAN	5585	18474		4157	14170
Ellice #123	150	526	34	51	179
Silver Creek #186	220	567	76	167	431
Russell #173	200	553	99	198	547
Shellmouth #181	285	733	100	285	733
Boulton #108	135	341	45	61	153
Hillsburg #137	175	559	39	68	218
Shell River #182	360	1050	100	360	1050
Park North	540	401	100	540	401
MANITOBA	2065	4730		1730	3712.69
BASIN TOTAL	7650	23204		5887	17882

Source: Statistics Canada Census of Agriculture (1996)

Over the last few years, rural pipelines have been developed in the Basin. These include the Assiniboine Rural Pipeline Association that provides water to 80 households near Kamsack and the Yorkville Utility Board that provides water to 120 households in the Melville, Yorkton, Rhein and Gorlitz areas. The Canora and District Rural Pipeline Association is proposing to build a rural pipeline in the Canora area utilizing a groundwater source. The Census data did not indicate source types.

3.2.3.2 Livestock

Livestock water uses include all significant types of livestock in all scales of operation, from small to intensive livestock operations. Livestock water use estimates were based on livestock populations determined from the 1996 Canada Census data (Table 3.7) and average daily water requirements using typical average outside or in-barn temperatures that occur through the year (Table 3.6). Table 3.8 provides the water use by livestock for 1996. Again the Census data did not indicate a type of source, however it is believed that surface water supplies most of the use for cattle, horses and sheep, while the rest of the livestock types are supplied mainly with groundwater.

Table 3.6 - Average Daily Water Requirements of Livestock

Type of Animal		Animal Size	Water Consumption (l/d)
Beef	Feeders*	250 kg	18.16
		408 kg	31.78
		567 kg	45.40
	Cows with calves**	590 kg	54.48
	Dry Cows**	590 kg	45.40
	Calves**	113 kg	9.08
Dairy	Milking Cow*	Holstein	136.20
	Dry Cows/Replacement Heifer	Holstein	45.40
	Calves	272 kg	22.70
Poultry	Broilers		0.1589
	Roaster/Pullets		0.1816
	Layers		0.2497
	Breeders		0.3178
	Turkey Growers		0.5902
	Turkey Heavies		0.7264
Swine	Farrow - Finish		81.72/sow
	Farrow - Late Wean	22.7 kg	29.54/sow
	Farrow - Early Wean	6.8 kg	24.97/sow
	Feeder	22.7-113 kg	6.81/pig
	Weaker	15 kg	2.27/pig
Horses			49.94
Sheep/ Goats	Ewes/does		9.08
	Milking Ewes/does		13.62
	Feeder lamb/kids		6.81

* For peak demand on hot summer days above 25°C - multiply by 2

** For peak demand on hot summer days above 25°C - multiply by 1.5

*** The numbers for all types of swine and milking dairy cows include wash water

Source: Alberta Agriculture (1998)

Table 3.7 - Prorated 1996 Number of Livestock in the Upper Assiniboine River Basin

Rural Municipality	Number of Livestock (Prorated by proportion of area in Basin)				
	Hens & Chickens	Pigs	Beef / Dairy Cattle & Calves	Sheep & Lambs	Horses & Ponies
Spy Hill #152	390	11	4295	N/A	215
Langenburg #181	1949	1221	5056	202	113
Churchbridge #211	22608	2937	12217	250	228
Saltcoats #213	9053	4283	5777	N/A	289
Cana #214	N/A	4136	6595	280	166
Stanley #215	N/A	107	1708	N/A	30
Calder #241	1306	N/A	7538	305	55
Wallace #243	2010	388	6760	62	78
Orkney #244	16448	394	10963	84	223
Garry #245	2092	252	10986	0	55
Ituna Bon Accord #246	277	N/A	1707	26	22
Cote #271	1061	296	7039	243	135
Sliding Hills #273	1211	232	2968	N/A	21
Good Lake #274	N/A	129	7403	304	28
Insinger #275	1785	119	7671	N/A	111
Foam Lake #276	459	560	4241	203	76
St Philips #301	273	N/A	1725	24	31
Keys #303	332	37	2837	1016	102
Buchanan #304	1345	10	3428	574	128
Invermay #305	1301	148	7194	135	228
Clayton #333	1147	1645	2180	63	22
Preeceville #334	N/A	242	11421	198	209
Hazel Dell #335	1003	254	9323	139	172
Sasman #336	1722	1247	4200	300	79
SASKATCHEWAN	67771	18648	145231	4409	2817
Ellice #123	203	1004	2019	0	247
Silver Creek #186	399	0	4585	0	608
Russell #173	24120	0	7984	0	2065
Shellmouth #181	892	0	9490	0	327
Boulton #108	67	0	3813	0	216
Hillsburg #137	2004	1086	3964	26	140
Shell River #182	2003	2302	18007	0	658
Park North	627	0	3140	0	389
MANITOBA	30315	4392	53002	26	4650
BASIN TOTALS	98086	23040	198234	4435	7467

Source: Statistics Canada Census of Agriculture

Table 3.8 - 1996 Water Use by Livestock in the Upper Assiniboine River Basin

Class of Livestock	Unit use (l/d per animal)	Number			Annual Water Use (dam^3/y)		
		Man.	Sask.	Total	Man.	Sask	Total
Hens & Chickens	0.18	30315	67771	98086	2	4	6
Pigs	9.08	4392	18648	23040	15	62	76
Beef/Dairy Cattle and Calves	45.4	53002	145231	198233	878	2407	3285
Sheep and Lambs	9.08	26	4409	4435	0	15	15
Horses and Ponies	49.94	4650	2817	7467	85	51	136
TOTALS					980	2539	3519

In addition to local approvals, livestock operations of sufficient animal density in Saskatchewan are considered to be "Intensive Livestock Operations" (ILOs) pursuant to *The Agricultural Operations Act* and are thus subject to regulation. The Act is administered by Saskatchewan Agriculture and Food and is applicable to any livestock operation in which the density of animal confinement is greater than one animal unit (AU) per 370 m^2. One AU equals 1.5 feeder cattle, 3 sows, 6 feeder hogs or 20 weanling piglets. In general, operations of less than 20 AU do not require an approval under the Act, operations between 20 AU and 300 AU may require approval if there are specific types of concerns. Operations over 300 AU require approval.

In Manitoba, ILOs may establish if they comply with municipal bylaws, development plans and zoning bylaws if enacted and if applicable, have received conditional use approval at the municipal level. The *Livestock Manure and Mortalities Management Regulations* under *The Environment Act* require a permit for all new or modified manure storage facilities. An annual manure management plan must also be submitted to Manitoba Conservation for all operations greater than 400 AU. A water rights licence is required by all operations consuming more than 25 m^3/d.

As of 1996 there were only two ILO operations in the Basin, both for beef production and both in Saskatchewan. Total water demand of the two was estimated to be 65 dam^3/year, or between one percent and two percent of estimated total livestock use. Thus, the vast majority of water use from livestock was for non-ILO operations and the estimated water use data are considered to be from non-ILO operations. As of 1998, the total estimated annual water demand from ILOs, all in the Saskatchewan portion of the Basin, had increased to approximately 150 dam^3/year from a total of four operations for both cattle and hogs.

3.2.3.3 Crop Spraying

The water used for the applibation of pesticides to agricultural lands was also estimated. Crops may receive one to four applications of pesticides and desiccants during the growing season.

Most manufacturers of pesticides recommend that their products be applied with 110 l/ha of water. To illustrate the scale of water use, a midpoint of 2.5 applications per year was used to estimate a total annual water use. Table 3.9 shows the cultivated area prorated by the percentage of rural municipality area in the Basin, while Table 3.10 shows the estimated annual water use.

Table 3.9 - Prorated Cultivated Hectares in the Upper Assiniboine River Basin

Rural Municipality	Cultivated Area (ha)	% of R.M. in Basin	Prorated Area (ha)
Spy Hill #152	35030	41	14362
Langenburg #181	46770	76	35545
Churchbridge #211	59798	97	58004
Saltcoats #213	50649	65	32922
Cana #214	45653	76	34696
Stanley #215	51754	22	11386
Calder #241	42287	100	42287
Wallace #243	63864	100	63864
Orkney #244	53770	100	53770
Garry #245	37997	96	36477
Ituna Bon Accord #246	44797	28	12543
Cote #271	48800	96	46848
Sliding Hills #273	55763	100	55763
Good Lake #274	42630	100	42630
Insinger #275	45448	100	45448
Foam Lake #276	86980	45	39141
St Philips #301	27513	33	9079
Keys #303	32671	82	26790
Buchanan #304	43684	100	43684
Invermay #305	34706	100	34706
Clayton #333	63626	21	13362
Preeceville #334	50912	80	40729
Hazel Dell #335	37332	79	29493
Sasman #336	75039	63	47275
SASKATCHEWAN	1177474		870805
Ellice #123	17174	34	5839
Silver Creek #186	34499	76	26219
Russell #173	29415	99	29121
Shellmouth #181	24343	100	24343
Boulton #108	17425	45	7841
Hillsburg #137	18896	39	7370
Shell River #182	41758	100	41758
Park North	11519	100	11519
MANITOBA	195029		154010
BASIN TOTALS	1372503		1024814

Table 3.10 - Estimated Pesticide Water Use

	Cultivated Area (ha)	Annual Water Use (dam^3/y)
Saskatchewan	1177474	239
Manitoba	195029	42
TOTAL	1372503	281

3.2.3.4 Irrigation

Backflood and sprinkler projects are the main irrigation uses in the Basin. Water use is not generally reported, therefore the only data available are from the regulatory agencies. Water use in Saskatchewan was estimated to be equal to the total diversion, i.e., the annual allocation plus losses. In Manitoba, the annual allocation was used. Most likely, the allocated volumes overestimate the actual water use, however these are the only data available. The irrigation use is summarized in Table 3.11. Appendix III contains project details.

Table 3.11 - Summary of Irrigation Project Use

	No. of Projects	Estimated Use (dam^3/y)
Saskatchewan	95	2150
Manitoba	11	1479
BASIN TOTALS	106	3629

3.2.3.5 Dugout Evaporation Losses

Dugout use in the Basin is primarily for livestock watering, but it can also be used for domestic use (household or yard), spraying, etc. Dugout evaporative losses are not the result of natural conditions and therefore an estimate should be included as a water use.

PFRA has provided financial assistance on 5576 dugouts with a total storage of 13,097 dam^3 in the Assiniboine River Basin in Saskatchewan. The average dugout size is therefore 2.35 dam^3 or 2350 m^3. A dugout of this volume typically has top dimensions of about 50 m x 22 m, or a surface area of 1100 m^2. Assuming an average surface area of 900 m^2 and average annual net evaporation of 0.425 m (850 mm gross evaporation and 425 mm precipitation), the average annual evaporation loss from each dugout is 380 m^3, or 2130 dam^3 from the 5576 dugouts in Saskatchewan (80 percent of the UARB). Assuming 20 percent of the dugouts are in Manitoba, the total evaporation loss would be about 2670 dam^3.

3.2.4 Reservoir Evaporation

The major reservoirs in the Basin include Lake of the Prairies, Good Spirit Lake and Theodore Reservoir. Minor reservoirs include those at the Canora and Kamsack weirs. The average annual net evaporation from these five reservoirs was estimated with the help of the WRMM model. The net evaporation volume for each month over the simulation period (1941-1995) was calculated for reservoir "r" and month "m" as follows:

$$D_{r,m} = E_{r,m} - P_{r,m} \tag{3.1}$$

$$V_{r,m} = D_{r,m} * A_{r,m} \tag{3.2}$$

where:

D = net evaporation depth;
E = gross evaporation depth;
P = precipitation;
V = net evaporation volume; and
A = reservoir surface area.

The monthly net evaporation volumes were then summed for each year, and the resulting yearly values averaged to provide the mean annual net evaporation from each reservoir shown in Table 3.12.

The mean annual net evaporation estimate for Good Spirit Lake shows a negative value. The installation of a control structure in the late 1980s has allowed for operation of the lake at a lower full supply level (FSL) than under natural conditions (Sask Water, 1986). The lower FSL has decreased the surface area of the lake hence there is less evaporation under regulated conditions and the net evaporation change due to the project is negative. There is justification in the concept of charging the entire evaporation from the lake as a water use because it is now controlled, regardless of the natural evaporation that would have occurred. However, since the net evaporation of the lake is in the vicinity of 18,000 dam^3/y or close to 30 percent of the estimated total Basin use of 64,000 dam^3/y, it was felt that an unjustified perception of total water use as compared to that which would occur under natural conditions would result.

Table 3.12 - Estimated Evaporation Use

Reservoir	Mean Annual Net Evaporation Volume (dam^3/y)
Theodore	1295
Good Spirit Lake	-1902
Canora	136
Kamsack	108
Lake of the Prairies	24309
BASIN TOTALS	23946

3.2.5 Wildlife Conservation Projects

Constructed wildlife conservation projects consist primarily of natural water bodies with an engineered structure at the outlet, serving to stabilize water levels to facilitate wildlife production. Although these projects have control structures, the surface area of the sloughs generally does not change significantly from natural conditions, thus evaporative losses are similar under both regulated and natural conditions.

These projects alter the natural flows of their watersheds and thus are required to be licenced. The majority of the projects have been developed and are operated by Ducks Unlimited. When licenced, the projects are granted allocations equal to the evaporation loss over the entire surface area of the water body, even though the incremental change in surface area from the project versus natural conditions is small. The net result is that the allocated annual volumes to these projects overestimates actual water use, often greatly. Without a detailed analysis of every project, the exact cumulative effect of the projects on water use is not known. An examination of the wildlife projects on a case by case basis was not possible for this Study. Therefore the net water use of the projects is assumed to be negligible.

Although the water has not actually been "used" and the cumulative change from natural flow conditions, although unknown, is not expected to be large, the availability of the water in time for other users may be affected. Further, as the water has been allocated, it is not available for alternate uses because of licencing. For the purpose of this Study, the water allocation is noted and is considered a use even though the effect of the projects may not be apparent in the runoff volumes of the various watersheds.

The number of constructed wildlife conservation projects in the Basin and their water allocations are shown in Table 3.13. The allocated volume for each project represents a water depth of 0.46 m over the area of the reservoir at the FSL. Inclusion of all the reservoirs into the WRMM model would perhaps have provided use estimates, however it would have been an enormous effort in terms of both modelling and estimation of natural inflows to each project, for only a limited benefit in model accuracy. Licencing details for the projects are provided in Appendix III.

Table 3.13 - Estimated Wildlife Conservation Project Use

	Number of Projects	Licenced Allocation (dam^3/y)
Saskatchewan	57	16640
Manitoba	8	2410
BASIN TOTALS	65	19050

3.2.6 Summary of Present Water Use

Table 3.14 summarizes the present withdrawal uses in the Basin. Graphical representations of the estimated water uses by source and by province are provided in Figures 3.2 and 3.3 respectively. Again, the wildlife conservation project allocations are included as water uses even though they do not use their allocation of water, primarily because that water is licenced to those projects and unavailable for other users.

Table 3.14 - Summary of Present Withdrawal Uses (dam^3/y)

Type of Use (% of Total Use)		Saskatchewan			Manitoba			Basin Totals		
		SW	GW	Total	SW	GW	Total	SW	GW	Total
Municipal (9%)	Recreation	0	40	40	0	0	0	0	40	40
	Urban Distribution	970	3930	4900	0	560	560	970	4490	5460
	Total Mun.	970	3970	4940	0	560	560	970	4530	5500
Agriculture (19%)	Irrigation	2120	30	2150	1290	190	1480	3410	220	3630
	Livestock			2540			980			3520
	Domestic			1400			370			1770
	Spraying			240			40			280
	Evaporation	2140		2140	530		530	2670		2670
	Total Ag.			8470			3400			11870
Industrial (6%)	Food Processing	0	30	30	220	0	220	220	30	250
	Cavern Washing	0	1940	1940	0	0	0	0	1940	1940
	Mining	0	1380	1380	0	0	0	0	1380	1380
	Total Ind.	0	3350	3350	220	0	220	220	3350	3570
Wildlife Conservation (30%)		16640	0	16640	2410	0	2410	19050	0	19050
Reservoir Evaporation (38%)		-360	0	-360	24310	0	24310	23950	0	23950
Grand Totals				33040			30900			63940

Note: May not add exactly due to rounding errors.

Figure 3.2
Water Use by Category and Source

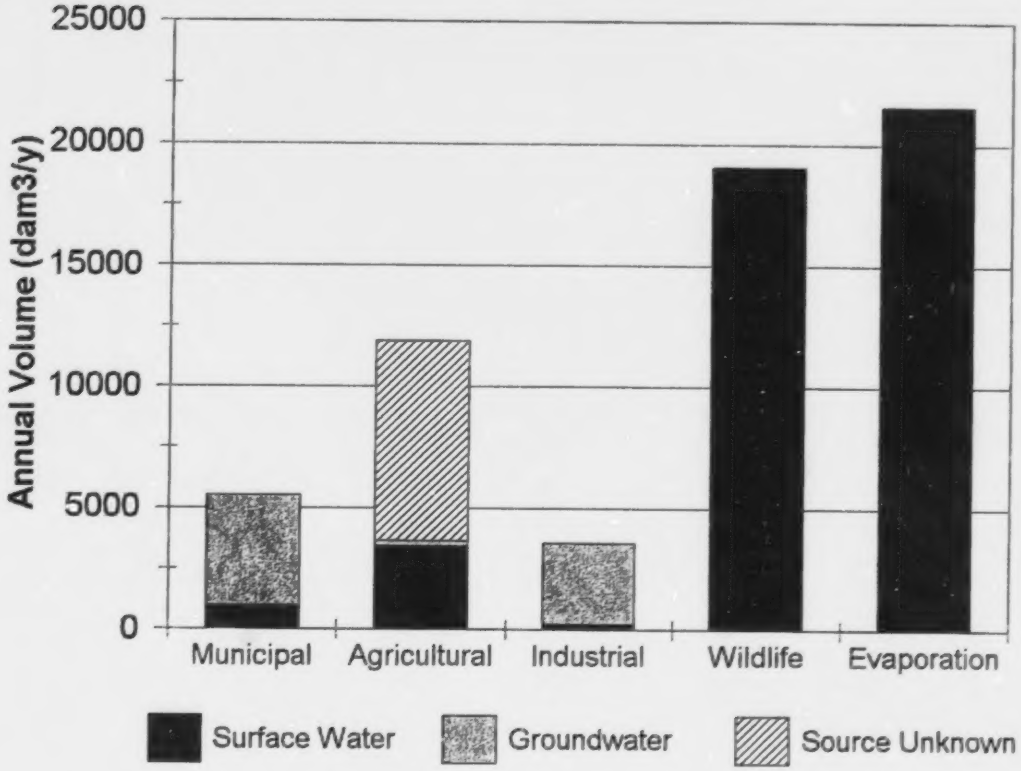
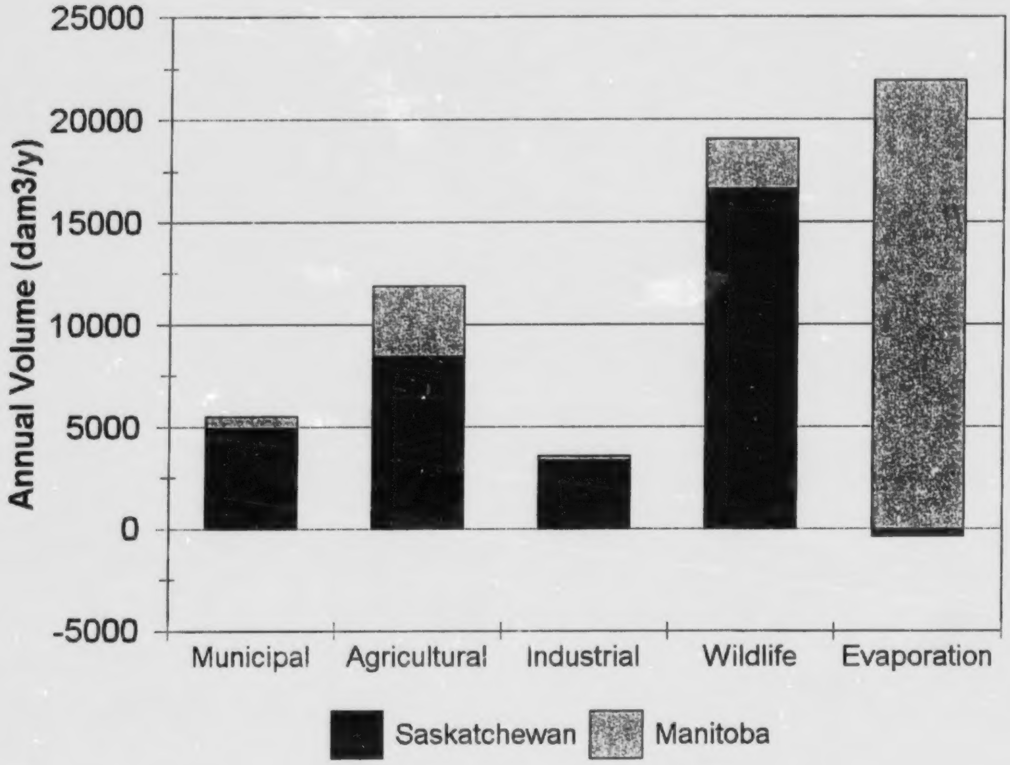


Figure 3.3
Water Use by Category and Province



The largest user of water in the Basin is evaporation, making up almost 40 percent of the total use as shown in the table. The next largest user based on allocation is wildlife conservation projects, which comprise about 30 percent of the total demand in the Basin. These two large users together make up two thirds of the use in the Basin. Agriculture uses make up approximately 20 percent of the Basin use. Municipal and industrial use represent 10 percent and 6 percent of the Basin use, respectively.

It was noted earlier that the wildlife projects may not actually use their water allocation. Assuming that the wildlife projects result in no net use of water as discussed in Chapter 3.2.5, then reservoir evaporation represents over 50 percent of the water use in the Basin, agriculture over 25 percent, municipal uses 12 percent and industrial use is less than 10 percent.

Within the category of evaporation, the largest user is Lake of the Prairies. High losses to evaporation are typical of prairie reservoirs. Wildlife conservation project allocations, if they are ever recognized as uses, would also comprise a significant water use.

3.3 Future Withdrawal Uses

In order to provide an indication of water demands in the future, withdrawal uses were estimated for all categories for 10 and 20 year time frames, i.e., the year 2010 and 2020. The methodology used for each type of use is described in its respective chapter.

3.3.1 Future Municipal Uses

With regard to methodology, municipal water demand projections are often based on projections of population and per capita consumption while accounting for such influences as industrial uses, precipitation, and cost influence. Such an approach requires significant data, including sufficient historical population and water consumption data to show past trends, a breakdown of industrial, institutional, commercial or residential use, and information on the cost of water. Detailed data on these factors are not available. A simpler approach to estimate future municipal uses was required.

Reliable population data are available from Statistics Canada, however a census is only conducted every five years. Many communities in both provinces have been experiencing population declines over the last 20 years, yet many have recorded annual increases in water consumption. Therefore, population alone could not be used as the basis for projecting future water uses.

The only detailed data available for most communities were the historical total water use. There is no breakdown of industrial, institutional, commercial or residential use. Therefore, future uses were based on projections of past total water consumption alone. Such estimates are based on the assumption that the observed historical trend will continue into the future. Projected water uses for each community for the years 2010 and 2020 are shown in Table 3.16. The methodology used to estimate the table values is described below.

Future water use projections for Saskatchewan communities were estimated by projecting historical trends using a non-linear projection. The following equation was used:

$$D = C_0(1 + i)^N \tag{3.3}$$

Where: D = Annual Water Demand (dam^3/y)
C_0 = Water consumption (dam^3/y) in the base year
i = rate of increase per year as a decimal fraction
N = number of years from the base year

The year 1996 was used as the base year because population data were available for all communities in the Basin and formed a common and consistent base year. Water use data were available for most communities in 1996, and when unavailable, were estimated to be the 1996 population multiplied by 270 l/d, a value used by Water Resource Consultants (1989) for this Basin.

The increase per year "i" was determined from historical water use data for each community. In cases where there was insufficient use data, a value of 0.63 percent was used based on the work by Olfert and Stabler (1999). Incidently, most of the "i" values calculated from the water use data were close to 0.63 percent. For some Saskatchewan communities, checks of the calculations were made using nonlinear regression which produced similar estimates. Table 3.15 lists the "i" values used in the analysis. High and low water use estimates were also calculated based on a per year increase in the "i" value established arbitrarily as 150 percent and 50 percent of the recommended "i" value for the high and low estimates respectively. Table 3.16 lists the estimated future uses in Saskatchewan.

Table 3.15 - Future Municipal Use Estimate "i" Values

Community	Low	Recommended	High
Yorkton	0.60%	1.16%	2.00%
Melville**	0.40%	0.91%	1.20%
Saltcoats	1.00%	3.14%	4.00%
Willowbrook	0.40%	0.87%	0.80%
White Spruce	0.00%	0.00%	0.00%
Canora	0.05%	0.11%	0.20%
Kamsack	0.50%	1.10%	1.50%
Sheho	0.30%	0.60%	0.90%
Kuroki	0.40%	0.94%	1.50%
Rama	0.30%	0.72%	1.00%
Mikado	0.40%	0.81%	1.20%
Fenwood	0.50%	1.14%	1.50%
Badgerdale (Cote I. R.)	0.00%	0.00%	0.00%
Ketchen-Standby	0.00%	0.00%	0.00%
All Others	0.30%	0.63%	0.90%

Table 3.16 - Estimated Future Municipal Water Use - Saskatchewan

	Water Use (dam^3/y)						
	1998 Actual	2010			2020		
		Low	Median	High	Low	Median	High
Badgerdale (Cote)	31*	31	31	31	31	31	31
Bredenbury	46.3	65	68	70	67	72	77
Buchanan	N/A	29	31	32	30	33	35
Calder	13.3	11	12	12	12	13	14
Canora	280	290	290	296	291	300	302
Churchbridge	N/A	113	118	122	116	126	134
Ebenezer	16.7	18	19	19	18	20	21
Endeavour	66.7	55	58	60	57	62	66
Fenwood	3.4	4.2	4.4	4.8	4.4	5.1	5.6
Gerald	16.8	19	20	20	19	21	22
Hyas	24.7	22	23	24	23	24	26
Insinger	0.7	1	1	1	1	1	1
Invermay	43.2	44	46	48	45	49	52
Jedburgh	1.9	2	2	2	2	2	2
Kamsack	315	302	330	347	318	370	403
Ketchen	1.3*	2	3	3	2	3	3
Kuroki	8.9	11	11	12	11	13	14
Langenburg	152	155	163	169	160	173	185
Lintlaw	45.8	46	48	50	47	51	55
MacNutt	12.2	13	13	14	13	14	15
Margo	26	28	29	31	29	31	33
Melville	643	652	702	729	668	755	821
Mikado	5.8	6.1	6.4	6.9	6.4	7.0	7.7
Preeceville	206	229	240	249	236	256	273
Rama	9	10	11	11	11	12	13
Rhein	18	28	29	31	29	31	33
Saltcoats	102	103	143	156	114	189	231
Sheho	26.8	36	38	40	38	40	43
Springside	63	76	80	83	78	85	91
Spy Hill	39.9	42	44	45	43	47	50
Stenen	16.6	17	17	18	17	19	20
Sturgis	134	167	175	181	172	186	198
Tadmore	2.2	2	2	2	2	2	2
Theodore	123	107	112	117	111	120	128
Togo	24.9*	20	24	25	21	29	33
Veregin	9.9	8	9	9	9	9	10
White Spruce	12	12	12	12	12	12	12
Willowbrook	N/A	6	7	7	7	7	7
Wroxton	7.5	11	12	12	12	13	14
Yorkton	2111	2377	2580	3516	2523	2860	3516
Hamlets	55*	57	60	62	59	64	68
Parks Facilities[2]	41*	43	45	46	44	48	51
TOTALS	4935*	5270	5669	6726	5509	6205	7118

* - estimated

For all communities in the Manitoba portion of the Basin, projection of future water uses involved examining historical trends in water use and projecting these trends to the year 2010 and 2020 by using least squares linear regression. Water use over time, water use vs. population, and the historical trend in per capita use were examined and the variables with the best correlation were used to project future water use for Manitoba communities. Upper, median and lower estimates were developed for each community and shown in Table 3.17. Table 3.18 summarizes the future municipal estimates for the Basin.

Table 3.17 - Future Municipal Water Use - Manitoba

Community		Water Use (dam^3/y)						
		1998 Actual	2010			2020		
			Low	Median	High	Low	Median	High
34	Angusville	10.6	11.4	12.0	12.6	12.9	13.5	14.3
35	Binscarth	48.5	59.0	62.1	65.2	69.1	72.7	76.3
36	Inglis	12.8	13.5	14.2	14.9	14.4	15.2	15.9
37	Roblin	292.5	340.1	357.9	375.9	387.1	407.5	427.9
38	Russell	198.5	229.5	241.6	253.7	267.1	281.1	295.2
	TOTALS	562.9	653.5	687.8	722.3	750.6	790	829.6

Table 3.18 - Summary of Future Municipal Water Use

	Water Use (dam^3/y)						
	1998 Actual	2010			2020		
		Low	Median	High	Low	Median	High
Saskatchewan	4935	5270	5609	6726	5509	6205	7118
Manitoba	560	654	688	722	751	790	830
TOTALS	5495	5924	6297	7448	6260	6995	7948

3.3.2 Future Agricultural Uses

3.3.2.1 Historical Trends in Agriculture

Agriculture in the Upper Assiniboine River Basin has followed the trends established in Saskatchewan, however the pace has been slower in the Basin with most change occurring in recent years. The major trend in agriculture has been a decline in farm numbers and rural populations as farm size increases. A trend to larger farm units with two or more operators has been established. Land tenure changes include a trend towards a large portion of land being rented. Off-farm employment has increased as income from farming has declined. Table 3.19 shows historical trends in various data.

Table 3.19 - Upper Assiniboine River Basin Historical Trends in Agriculture

Year	1956	1966	1976	1986	1991	1996
Population of R.M.s	57582	43,930	33,609	28,681	25,684	23,204
Number of Farms	13873	11,486	9,064	7,650	7,332	6,578
Average Farm Size (ha)	164	203	257	310	336	345
Area in Annual Crops (ha)	728048	847964	837737	----	1247221	1226230
Area in Summerfallow (ha)	427258	480842	560212	----	303960	235607
Tame Hay/Forage/Fodder	39511	71506	114713	----	130665	146320
Improved Pasture (ha)	41343	68842	91616	----	120660	130428
Total Farmed Area (ha)*	2275172	2331658	2329448	2371500	2463552	2269410
Total Cattle and Calves	234,446	286,758	334,406	232,517	230,181	274869
Number of Beef Cows	----	----	----	89,782	98,658	106104

*** - Calculated as number of farms multiplied by average farm size**

Source: Statistics Canada Census of Agriculture

Livestock production in the Basin has been primarily cow-calf beef operations producing feeder calves for feedlots. The cow-calf beef operations are primarily located on Class 3, 4, 5 and 6 land which are marginal for cash crop production. The historical trend of beef production on marginal land has resulted in most beef operations being located along the Manitoba-Saskatchewan border and along the Assiniboine and Whitesand River systems.

Pork production has developed in several R.M.s with production occurring in small to medium sized family owned operations. Most of the pork production has developed in the past twenty years. In recent years large hog operations have been developed by corporate farms (discussed further under future water uses in agriculture). As of 1998, two such operations were located near Preeceville and Theodore.

Development of the dairy industry began in the late 1960s with the establishment of a dairy processing plant in Yorkton. Consequently, dairies were located primarily in the Yorkton area. In recent years many of the dairies have sold their milk quota to producers in other areas of Saskatchewan. Dairy production has declined in the Basin with reduced processing operations at the dairy plant in Yorkton.

Poultry production has developed due to a processing plant located at Wynyard. With increased consumer demand the poultry industry has grown in the Basin, however poultry production remains a minor agricultural industry.

Trends in crop production have included reduced tillage, direct seeding, reduced summerfallow, increased use of crop inputs and an increase in the number of crops grown. Economic trends in grain farming have included rising input costs, higher freight charges and lower commodity prices resulting in a decline in the profitability of grain farming. Land values in the Upper Assiniboine River Basin have remained stable after a period of decline. In the Basin, wheat and canola have been the main crops followed by barley, oats, peas and flax. The number of hectares of peas has increased dramatically since 1987. Special crops such as mustard, canary seed and lentils have also been produced. In recent years caraway, coriander, borage, chick peas, hemp, corn and quinoa have also been grown on a field scale.

Forage production has primarily been done to provide grazing and winter feed for on farm use by beef and dairy animals. An alfalfa processing plant at Norquay, Saskatchewan began operating in 1991 and processes alfalfa from 14,000 ha (35,000 acres) annually. A timothy processing plant at Russell, Manitoba was established in 1996 to process timothy grown throughout the Basin. Forage seed production has occurred on a very limited basis in the Basin.

3.3.2.2 Future Trends in Agriculture

Future trends in agriculture are assumed to be a continuation of rural depopulation, larger grain farms, increased forage and beef production, increased hog production, and increased reliance on off-farm income.

The number of people living in the rural municipalities is expected to continue declining but the rate of decline is expected to decrease. The level of services including electricity, natural gas, telephone and water provided to farms will greatly influence the population of rural municipalities. Farmsteads with good services will most likely remain inhabited. Rural water pipelines will play a major role in maintaining rural populations.

Farm size is expected to increase at a rapid rate as the economics of grain farming continue to favour large farm operations. The larger farms will often have two or more operators, utilize a corporate structure and have more than one half their land base made up of rental land.

Forage and beef production will increase as marginal land is seeded to forages. Cow numbers are expected to increase as the amount of pasture increases. The number of beef animals fed on farms will increase as backgrounding increases in popularity. Backgrounding refers to the growing, feeding and managing of steers and heifers from weaning until they enter a feedlot and are placed on a high concentrate finishing ration. The Basin is expected to be an exporter of hay and processed forages.

Hog production is also expected to increase utilization of feed grains produced in the Basin. Large hog barn complexes will be constructed by agricultural corporations.

Off-farm income will continue to play an important role in obtaining adequate income for farm families. Employment opportunities for rural residents will be greatest near large communities. Specialized livestock and crop enterprises that may include value added activities will also add income to farm operations.

3.3.2.3 Future Water Uses

(1) Domestic

The rate of depopulation of rural municipalities is expected to decline as many people will remain on farms as a life style choice relying on off-farm income and retirement income. Demand for water will decline, but demand for a consistent supply will be high. Rural pipelines may develop to provide more reliable water supplies. Dugouts, wells, and rural pipelines will continue to provide water to farmsteads.

There are no data available on rural population projections specific to the Basin. Olfert and Stabler (1999) estimated that the total rural population of Saskatchewan would decrease by 0.61 percent per annum from 1996 to 2005. An estimate of potential future rural water use can thus be made if that population rate decline is extrapolated to the years 2010 and 2020. Based on a per capita consumption rate of 270 l/d. The total water use by rural households can then be calculated using equation (3.3) with $i = -0.0061$. The estimated rural domestic use would then be approximately 1620 dam^3/y in 2010 and 1520 dam^3y in 2020, compared to the estimated present use of 1770 dam^3/y.

(2) Livestock

(a) Non-ILO Production
Beef cattle numbers are expected to rise dramatically as marginal land is converted to forage production for grazing and winter feed production. Coghill and Brown (1998) analyzed the economics of converting marginal land to forage in Saskatchewan. For Canada-Saskatchewan Crop Insurance Risk Area 14, which includes most of the Upper Assiniboine River Basin, the study found that land with Crop Insurance ratings of K, L, M, O and P would be converted to forage providing an additional 19,784 hectares (48,886 acres) of forage which would provide for a potential increase of 41,899 cattle. Brown and Ayars (1999) studied the economics of grain farming and beef production. Grazing steers were found to be the most profitable enterprise in the Black Soil Zone. Producing forage for cow-calf operations was the second most profitable enterprise in the Black Soil Zone. Since the Upper Assiniboine River Basin is located in the Black Soil Zone, it is anticipated that beef production will increase dramatically in the Basin.

Existing cattle producers are expected to expand their herd size and new beef producers are also expected as grain producers develop cow-calf and backgrounding operations. Cow numbers in the Basin increased by 10 percent from 1986 to 1991 and by 8 percent from 1991 to 1996 (Statistics Canada Census of Agriculture).

Total cattle and calves increased by 19 percent from 1991 to 1996 (Statistics Canada Census of Agriculture). In the long term, beef cow numbers are expected to increase by 2 parcent each year. Water demand will increase proportionately with reliance on dugouts as the main water source for beef herds, therefore the future water demands were estimated to be the present use increased 2 percent per annum.

Pork Central of Saskatchewan Agriculture and Food estimates that pork production will increase by 10 percent in 1999 and 15 percent in 2000. Production increases in the Basin will be consistent with the Saskatchewan Agriculture and Food estimates. Beyond 2000, additional expansion will be dependent on the economics of pork production.

Water use for other smaller classes of animals (chickens, sheep) are relatively small and were assumed to remain stable, as was water use by horses. Table 3.20 lists estimated future water uses by livestock.

Table 3.20 - Estimated Future Livestock Use (Non-ILO)

Class of Livestock	Annual Water Use (dam^3/y)		
	Present	2010	2020
Hens & Chickens	6	6	6
Pigs	76	84	96
Beef/Dairy Cattle and Calves	3285	4334	5284
Sheep and Lambs	15	15	15
Horses and Ponies	136	136	136
TOTALS	3519	4575	5537

(b) Intensive Livestock Operations

As with other parts of Western Canada, the Upper Assiniboine River Basin has experienced, and will likely continue to experience, a growth in intensive livestock operations. The first ILO activity in the Basin has been cattle feedlots. Hog ILOs were not introduced until late-1998.

To correspond with the municipal and rural domestic water demand study, calculations started in 1996. The year 1996 had been presented as the present base year because that was when the last census was taken.

A number of family-run cow-calf operations exist in the Basin and some of these operations are expanding and may require permits in the future. The 1996 cattle ILO use was estimated to be less than 2 percent of the total use by cattle for that year. Although growth in the beef ILO industry is expected, the increased numbers relative to the entire Basin population are likely to be small and increases therefore are included in the overall estimated growth of 2 percent per year in total cattle for the Basin.

The Upper Assiniboine River Basin is within an area considered to have an economic advantage to produce hogs due to the price and availability of feed grains (Saskatchewan Agriculture and Food, 1998). A sparse population also makes locating a hog production unit less difficult. The preferred water source for hog barns is groundwater.

As of 1996 there were no hog ILOs in the Basin, therefore all the water use estimated from the 1996 census data represents use from non-ILO operations. Hog ILO developments in the Upper Assiniboine River Basin have taken place since that date. Based on known and proposed developments since, estimated water demand for 1996-2000 was projected.

Assuming 1998/1999 unit uses from Table 3.21 and an estimated average growth of about 5000 to 6000 animal units per year, a 100 dam^3 annual water demand increase has been projected in this Study for the hog ILO sector to last until 2005. A modest annual increase is projected to last until 2010 after which no increase in water demand was forecasted. That assumes the hog ILO industry would experience negligible growth and/or better water use efficiency created by future technical innovation. Table 3.22 presents the projected annual water demand from hog ILO activity in the Basin. Even at the forecast level of water use from hog ILOs by 2010, consumption only represents approximately 15 percent and 6 percent of the total livestock and total agricultural use respectively.

Table 3.21 - Unit Water Consumption Uses for Hog ILOs

Type	Number	Consumption (l/d)
Farrow/Breeding	2400 Sows	18.75
Nursery	8800 Piglets	2.05
Feeder/Finishing	17600 Feeders	3

Table 3.22 - Estimation of Projected Water Demand from Hog ILOs

Year	Estimated Annual Water Demand (dam^3/y)
1996	0
1997	0
1998	50
1999	170
2000	280
2001	380
2002	480
2003	580
2004	680
2005	780
2006	800
2007	800
2008	900
2009	900
2010-2020	1000

(3) Application of Pesticides

In the Upper Assiniboine River Basin the amount of crop land sown to annual crops will be reduced by 2 percent due to conversion of marginal land to forages. Water use for applying pesticides will increase in the order of two fold due to multiple applications of pesticides on crops. The preferred water source for use with pesticides is surface water from dugouts. Water from urban communities and community wells is also utilized for applying pesticides.

If the use of water for pesticide application doubles for the year 2010 and then remains at the same level until 2020, the use would be estimated at 560 dam^3/y for both cases.

(4) Irrigation

Without the addition of major irrigation projects, the future use of irrigation is expected to remain constant, as there are not any known planned major irrigation projects. Future irrigation water uses will mirror that of present development levels.

The potential exists for small irrigation projects ranging in size from less than one to five hectares (2.5 to 12.3 acres) to satisfy niche markets. Examples of such projects are market gardens and the production of seed potatoes, turf grass, specialty forage seed, bare root tree nursery and small fruits.

Limited opportunities for large scale irrigation exist for the production of small seeded cash crops, potatoes, alfalfa and silage. Commodity prices and supply will determine the viability of large scale irrigation.

3.3.3 Other Future Withdrawal Uses

Changes in the other Basin uses (industrial, evaporation, and wildlife conservation) are not expected to be significant in the near future unless major projects are located within the Basin. There are no known major industrial developments planned that would seriously affect water availability. Also, there are no known major reservoirs planned which would significantly alter the evaporative uses in the future. Finally, Ducks Unlimited has changed its focus from large scale wetlands projects to upland areas and no significant wetlands projects are likely to be developed in the near future. As such, uses from constructed wetland projects are not expected to differ significantly in the future.

3.3.4 Summary of Future Uses

The future use estimates for the Basin were rounded off and are summarized in Table 3.23. The estimates are shown graphically with present use estimates in Figure 3.4.

Figure 3.4
Future Water Use Estimates by Category

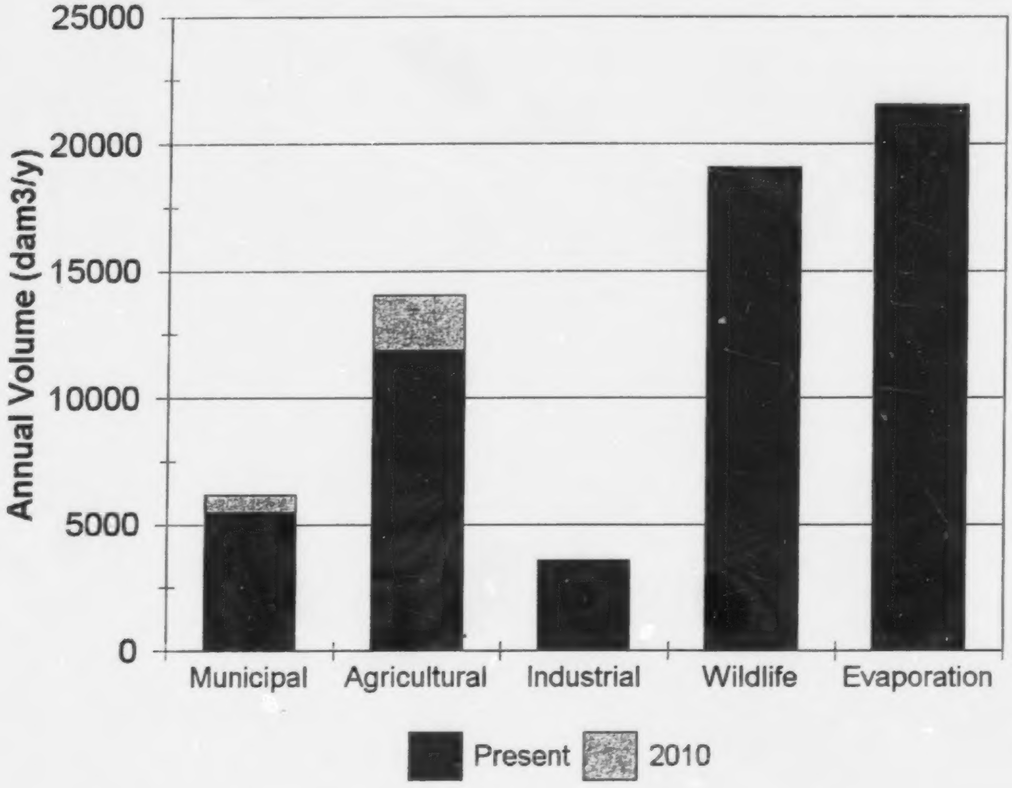


Table 3.23 - Summary of Present and Future Withdrawal Uses

Type of Use		Estimated Present Use (dam^3/y)	2010		2020	
			Annual Use (dam^3/y)	% change fr. present	Annual Use (dam^3/y)	% change fr. present
Municipal		5500	6200	13	7000	27
Agriculture	Irrigation	3630	3630	0	3630	0
	Livestock	3520	5580	59	6540	86
	Domestic	1770	1620	-8.5	1520	-14
	Spraying	280	560	100	560	100
	Evaporation	2670	2670	0	2670	0
	Total Agric.	11870	14060	18	14920	20
Industrial		3570	3570	0	3570	0
Wildlife Conservation		19050	19056	0	19056	0
Reservoir Evaporation		23950	23950	0	23950	0
Grand Totals		63940	66830	5	68490	7

3.4 Instream Uses

3.4.1 Apportionment and Downstream Demands

Saskatchewan is obligated to pass on 50 percent of the natural flow of the Assiniboine River to Manitoba under the terms of the Prairie Provinces Water Board 1969 Master Agreement on Apportionment. An initial study of natural flows and Saskatchewan's use found that the province was only using approximately 5.5 percent of their share of the average annual natural flow of the Assiniboine River at the Saskatchewan-Manitoba boundary as of 1977 (Prairie Provinces Water Board 1980). Saskatchewan water use would have had to increase some 20 fold in the last 20 years for the province to presently use its share of the water. This has not occurred. Since there are no large water use projects being planned in Saskatchewan, apportionment will not be an issue in the immediate future.

Water demands below the confluence of the Assiniboine and Qu'Appelle Rivers can affect water management in the Basin insofar as the operation of the Shellmouth Dam is concerned. Within the context of this Study, these demands are not specifically incorporated into the analysis and the model. These demands are excluded since the order of use of water in the reservoir is first for irrigation and industrial users within the Basin, second for maintaining a minimum flow below the reservoir and finally for reservoir based recreation. Downstream flow needs are addressed to a degree in the minimum channel flow below the reservoir. Any extra flow, including flood waters, is stored in the reservoir or passed downstream subject to channel flow restrictions as necessary.

3.4.2 Instream Flow Needs for Fisheries

3.4.2.1 Background Information

For aquatic ecosystems, the ideal situation is to have an unregulated river and completely natural flows. However, this is not possible as other uses share the resource. One way of recognizing that aquatic ecosystems do require flows and a water supply is to develop some type of instream flow recommendations, Any instream flow recommendation is an attempt to provide tolerable flows in light of other competing uses and represents a compromise at best, but nonetheless allows for at least an examination of the magnitude of flows and water volumes thought to be needed to maintain ecosystems.

The concept of instream flow needs is examined here from primarily a fisheries perspective, although it also reflects the general ecosystem to some degree. It identifies the fish species in the Basin, the role of different aquatic habitats, considerations of human activities on fish and fish habitat, and finally, the rationale, calculation methods and suitability of instream flow requirements.

(1) Fish Species and Distribution

The Upper Assiniboine River Basin has a diverse fish community, with established populations of 32 species of fish (Appendix IV). Common species include northern pike, walleye, perch, burbot, mooneye and rock bass. Four members of the sucker family are present, including white sucker, quillback, silver redhorse and shorthead redhorse. Two members of the catfish family, the brown bullhead and the stonecat, are present. In addition, eighteen species of smaller fish belonging to the minnow and stickleback families and the darter subfamily, are also found in the Basin.

A small member of the lamprey family, the chestnut lamprey, has been collected at several locations in the Basin. This species spends several years as an inactive larva in the bed of streams followed by about 18 months as a predatory adult. The chestnut lamprey is listed as vulnerable by the Committee of Endangered Wildlife in Canada. This listing means that the species is not in current danger but is of special concern due to characteristics that make it sensitive to human activities or natural events.

All the species listed in Appendix IV are native species with the exception of the common carp which invaded the Assiniboine River watershed some time after its introduction to North America from Europe.

Several non-native trout species are stocked in smaller lakes in the Basin. Populations of these species typically are not self-sustaining but must be maintained by continued stocking programs. Brown trout have recently been stocked in the Shell River in Manitoba and may eventually establish a self-sustaining population (Bruce Wright, SERM, pers. comm.).

Appendix V contains a list of collections of fish species from streams in the Basin. With the exception of Lake of the Prairies, collections from lakes in the Basin are not included in the list.

(2) Fisheries

Most harvest of fish in the Upper Assiniboine River Basin is by recreational fishermen. Information derived from sport fishing surveys in 1990 and 1995 (Joerissen and Brickley 1998; Carl Wall, Manitoba Conservation, pers. comm.) indicates that approximately 150,000 angler-days of fishing effort are expended annually in the Basin. The total angling harvest in the Basin is estimated at 285,000 fish per year, consisting mainly of northern pike, walleye and perch.

The estimated angling effort in the Upper Assiniboine River Basin is about 3 percent of the total combined angling effort for the provinces of Manitoba and Saskatchewan. Angling harvest in the Basin is about 2 percent of the total combined angling harvest for the two provinces. The harvests are relatively small in comparison to provincial totals but several locally important angling waters occur in the Basin, including Lake of the Prairies, Good Spirit Lake and Fishing Lake.

Several bait fishing licences are issued annually in the Basin. Minnow species such as spottail shiner and emerald shiner are harvested and preserved for resale to anglers. Most production originates from Lake of the Prairies with annual harvests of about 12,000 kg/year on the Manitoba side of the border (Bruce Wright, SERM, pers. comm.) and about 1000 kg/year on the Saskatchewan portion of the lake (Tom Maher, SERM, pers. comm.).

Domestic harvest of suckers occurs at several locations in the Basin. Typically, suckers are dip netted during the spring spawning run. Depending on spring conditions, up to several dozen licences may be issued annually in Saskatchewan with harvests of up to a few thousand kilograms. In Manitoba, suckers may be dip netted under authority of a sport fishing licence therefore, estimates of the number of participants and harvests are unavailable but the activity is believed to be fairly popular (Bruce Wright, SERM, pers. comm.).

(3) Fish Habitat in the Upper Assiniboine River Basin

Fish habitat is defined under the *Fisheries Act (Canada)* as the "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." In effect, almost any aquatic area to which fish have access is fish habitat.

Habitat requirements vary according to fish species, life stage and time of year. For example, species such as walleye and white suckers require clean gravel and cobble in streams or along windswept lake margins. Northern pike require shallow, vegetated areas in marshes or flooded terrestrial grasses along the margins of lakes or streams for spawning purposes. Nursery areas for many species of fish are typically shallow, vegetated areas that provide abundant food and cover from predators. Larger fish seek deeper water for feeding during the summer growing period and require permanent, deep water bodies for overwintering.

Nonpermanent wetlands are often important fish habitat. For example, seasonally inundated marshes and hay flats bordering lakes and streams provide valuable spawning areas for pike and perch. A water body need not contain fish species of economic importance for it to constitute fish habitat. For example, streams or marshes supporting only minnow species or aquatic invertebrates may be considered to be fish habitat since these areas provide a food supply for other fish species.

Since fish need different types of habitat during different life stages and at different times of year, the migration routes connecting these habitat types are of critical importance to the survival of fish populations.

The value of aquatic habitat in lakes and large rivers is easily recognized. Other kinds of habitat are less obvious but may be equally important in aquatic systems. Small, semi-permanent streams often support only a limited number of fish species but population densities in these streams can be very high. Such streams can contribute large amounts of forage fish and invertebrates to larger, downstream water bodies (Zale *et al.* 1989). In the Upper Assiniboine River Basin, many small streams flow only in the spring and early summer. In addition to producing forage fish, these small, intermittent streams can be important spawning habitat for larger fish species such as northern pike, provided that flows persist long enough in the spring to allow successful downstream movement of the newly hatched fry. A study in Ontario found that the downstream drift of fish fry in an intermittent stream was comparable to drift in an adjacent perennial stream, suggesting that intermittent streams may be important nursery areas (Dance and Hynes 1979, in Zale *et al.* 1989). Small streams greatly outnumber large streams in a watershed (Gordon *et al.* 1992), therefore, small streams contribute relatively large numbers of forage fish and young-of-the-year fish to downstream lakes and rivers.

Water bodies in the Upper Assiniboine River Basin that are of particular importance to fish include many of the larger lakes such as Good Spirit and Fishing lakes. These lakes typically contain a variety of species including those actively sought by anglers, such as northern pike, walleye and perch. Lake of the Prairies, a man-made reservoir, supports the largest sport fishery in the Basin. The main stem Assiniboine River and Whitesand River both provide year-round habitat for fish (Al McCutcheon, SERM, pers. comm.). Numerous species of fish, including pike and walleye, have been collected as far upstream as Rockford on the Assiniboine River and the Theodore Dam on the Whitesand River. Tributary streams of these rivers, such as Yorkton Creek, Crooked Hill Creek, Wallace Creek and Stony Creek (near Stenen), support spawning runs of northern pike. Spawning runs of both northern pike and walleye occur in Spirit Creek which flows into Good Spirit Lake. Even smaller tributary streams in the Basin have been found to support a variety of forage fish species, and in some cases, function as spawning areas for northern pike (Appendix V).

(4) Impacts of Human Activities on Fish and Fish Habitat

(a) Migration Barriers

A variety of human activities have had an impact on fish and fish habitat in the Upper Assiniboine River Basin. Construction of dams, weirs and road crossings have resulted in complete or partial blockages of fish migrations at several locations in the watershed. Unrestricted movement throughout a river system is important to the overall health of fish populations. Different types of habitat required at different stages of a fish's life cycle may occur considerable distances apart. For example, fish may overwinter in a large lake or river but suitable spawning areas may be located as much as one hundred kilometers or more upstream. Without free access to the upstream spawning areas, the population may be reduced in abundance. Since fish often travel great distances for spawning, the existence of a barrier on part of a river can have impacts on fish populations in lakes or rivers considerable distances downstream.

Dams typically form complete barriers to fish migration unless equipped with fishways. Weirs may constitute complete barriers in low water years but may be overtopped by flood waters during periods of high runoff, reducing impacts to fish migration. Only one water control structure in the Upper Assiniboine River Basin, the Kamsack Weir, is equipped with a fishway. The existence of dams in the Upper Assiniboine River Basin may have had beneficial side effects by helping to restrict the spread of invasive species such as the common carp.

Road crossings of streams have potential to block upstream movements of fish. Undersized culverts result in excessive water velocities within the culvert and fish are unable to proceed upstream through the culvert. In addition, improperly installed culverts may result in waterfalls at their downstream ends which form physical barriers to fish passage. As with dams and weirs, the main impact of substandard road crossings is disruption of upstream spawning migrations.

(b) Land Use Impacts

Large scale land use changes such as bush clearing and drainage of wetlands for agricultural purposes indirectly affect fish habitat through changes to the hydrological regime. Without human interference, streams normally establish stable morphometric characteristics. The stream cross-sections (width-depth ratio) and meander patterns are relatively stable and are determined by the normal range of stream discharges that occur over the long term. As a result of this stability, erosion and sedimentation in the stream are minimized. Land clearing and drainage can allow faster runoff and higher peak flows which can destabilize the channel morphometry (Wang *et al.* 1997). As a result, instream erosion and sediment deposition can increase. Excessive sedimentation in the stream affects fish and fish habitat by covering spawning beds and eggs, covering food production areas, reducing the depth of overwintering pools, abrading gills of fish and aquatic insects and reducing the foraging ability of sight feeding fish.

Altered flow regimes due to land use changes can also affect fish migrations. Land clearing and wetland drainage may contribute to spring flows of high intensity but short duration. The high spring flows encourage upstream migration of fish. However, flows may not remain sufficiently high for a long enough period to allow the adult and young-of-the-year fish to return downstream without being stranded in pools and beaver ponds.

(c) Flow Modifications

A major impact to fish and fish habitat results from the intentional modification of flows in streams from water control structures and diversions. Typically, dams and diversions result in overall reduced flows as water is diverted for offstream uses. This results in reduced quantity and quality of habitat downstream of the structures. Numerous physical and biological changes occur downstream of water control structures (Baxter and Glaude 1980). One of the most notable effects is the decrease in annual flow variations of the stream. The normal, high spring flows are dampened as the spring runoff is captured in reservoirs and the normal low summer and winter flows are increased as water is released from the reservoirs. The annual flow regime to which fish and aquatic life are adapted is not expected to occur which can cause downstream aquatic communities to change and may cause productivity of aquatic populations to decline (Baxter and Glaude 1980). Numerous studies in North America have shown this biological relationship with flow modification to exist after dams were constructed.

3.4.2.2 Instream Flow Needs (IFN) for Fish

(1) Rationale for Instream Flow Requirements

In the context of water supply and use in the Upper Assiniboine River Basin, the most important fisheries issue is the instream flow needs of fish. Instream flow refers to the amount and timing of discharges in a stream. Instream flows may be greatly modified by human intervention in the form of water control structures and water diversions. For fish in streams, flow is a critical component of habitat. The volume of flow in a stream directly affects the quantity and quality of habitat by determining the water depth, the wetted width of the stream and the water velocity. Indirectly, the volume of flow affects water temperature and oxygen concentration. These flow dependent parameters may either increase or limit the carrying capacity of a stream for fish (Hardy *et al.* 1994). Other indirect impacts to fish from changes to stream flows include changes to food production, availability of spawning substrate, availability of overwintering habitat and ability to migrate between different habitat areas (Leathe and Nelson 1986).

Instream flow assessment is particularly important on highly developed streams where significant amounts of water are allocated to offstream uses. At the present time, relatively little flow in the Basin is allocated to offstream uses. The Upper Assiniboine River Basin Study provides an opportunity to ensure that adequate stream flows are reserved for fish and other aquatic life before major developments occur. Since water projects that may have a harmful effect on fish habitat are subject to federal legislative requirements, it is important that instream flow needs be considered as part of any basin planning study.

(2) Instream Flow Assessment Methodologies

Fish populations in streams require particular flows to meet their various life requirements. Instream flow needs assessments attempt to predict the amount and timing of stream flows required to maintain fish populations at an acceptable level by providing suitable flows at various times of year to support the life processes of the aquatic community. In addition, adequate flows are required to maintain the morphometry of the stream channel to ensure long term existence of fish habitat.

A wide variety of instream flow assessment methodologies have been developed and these are generally grouped into three basic categories (PPWB 1999):

- Discharge methods - Discharge methods assess historical stream flow records and often express the instream flow requirements as fixed percentages of mean or median, annual or monthly flow. These are simple methods requiring no field work. While there is an implied relationship between the volume of stream flow and fish production none of the discharge methods provide empirical evidence of this relationship.

- Hydraulic rating methods - Hydraulic rating methods employ data from single or multiple transects on a stream to develop a relationship between discharge and physical habitat availability at a specific location. The method may be useful if particular habitat types or locations are known to be critical to a fish population. Considerable field work may be required.

- Habitat preference methods - Habitat preference methods develop a relationship between discharge and weighted usable area of a stream. These methods allow quantitative comparisons of available habitat for a variety of species over a range of possible discharges. While habitat preference methods are generally acknowledged as the most useful of the instream flow assessment methods, they involve considerably more field work and expense than the other methods.

The choice of an instream flow assessment method should be based on the specific management objectives for a river or watershed and the purpose for which the study is needed. In the present case, the Upper Assiniboine River Basin Study is a broad planning exercise intended to address overall water needs of the watershed as opposed to a localized study directed at a particular water development proposal for a specific location. For this situation, a discharge method is an appropriate means of determining instream flow needs. It is emphasized, however, that this method is being applied in the current Study only as a general planning tool. If specific water development projects are contemplated in the Basin in future, the water requirements of the project and the hydrology of the stream should be thoroughly reviewed. In most cases, a specific, comprehensive study will be warranted. This is particularly important for streams where existing uses have begun to approach the capacity of the stream to supply water.

(3) Tessmann Method for Instream Flow Needs Estimates

Two major discharge methods are commonly used in western North America. These are the Tennant method and the Tessmann modification of the Tennant method (PPWB 1999). The Tennant method (Tennant 1976) divides the year into two periods, April-September and October-March. Depending on the level of protection desired, a particular percentage of the mean annual flow (MAF) is prescribed for each of the two periods. The method was refined by Tessmann (1980) who divided the year into twelve monthly periods each of which is assigned to one of three categories defined by the relationship between the mean monthly flow and the mean annual flow (Table 3.24). Flow recommendations are made on a monthly basis, with those months having naturally high flows, i.e., spring, prescribed relatively high flow recommendations, those months having naturally low flows prescribed flows equal to the existing, low flows, and months with mid range flows assigned mid-range flow recommendations. The resulting hydrograph resembles the natural hydrograph but with dampened peaks.

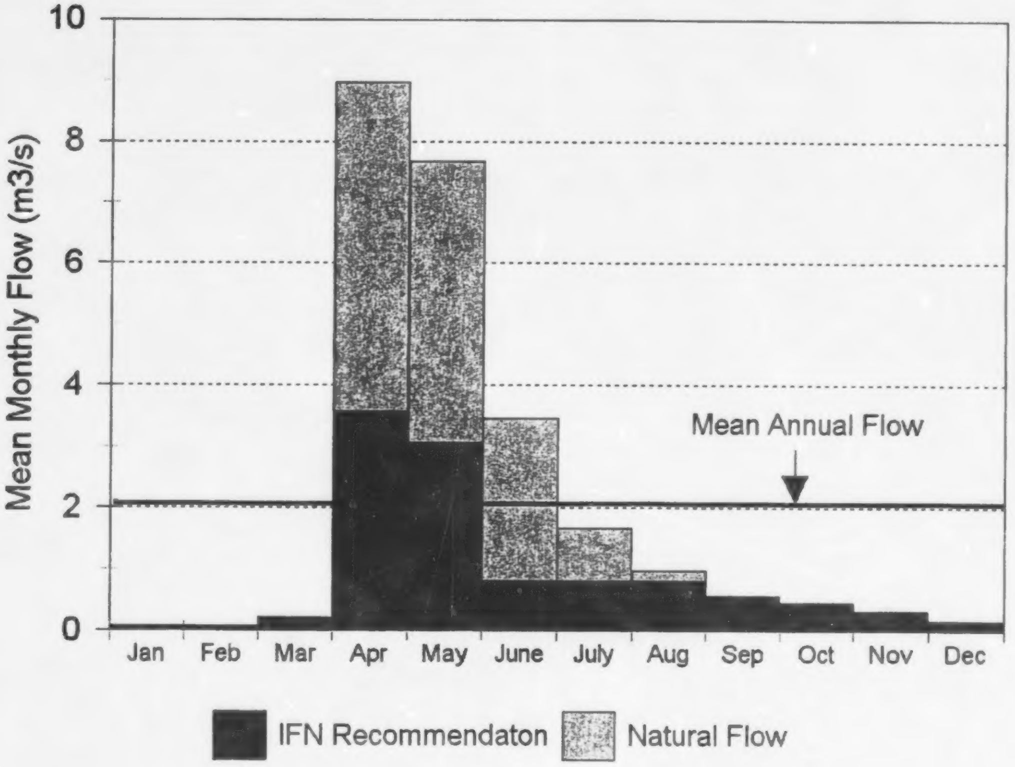
Table 3.24 - Determination of Instream Flow Recommendations Using the Tessmann Modification of Tennant's Method.

Category	Minimum Monthly Flow Recommendation
MMF < 40% MAF	MMF
MMF > 40% MAF and 40% MMF < 40% MAF	40% MAF
40% MMF > 40% MAF	40% MMF

In addition, a 14 day period of 200% MAF is required during the month of highest flow for channel maintenance. (MMF - Mean monthly flow, MAF - Mean annual flow)

The monthly flow recommendations are intended to provide adequate flows for the life processes of fish and the aquatic organisms on which they feed. In addition, the Tessmann method provides for spring flushing flows to maintain channel form and flood streamside habitat. This is accomplished by requiring a two week period with 200 percent of mean annual flow during the month of highest flow. This usually occurs in April or May. Consequently, the April or May flow recommendation consists of a two week period with flows fitting one of the three categories outlined in Table 3.24, and a two week period with a higher flow for flushing purposes. Table 3.24 shows how monthly and flushing flows are determined using the Tessmann method. Application of the Tessmann method to a stream in the Basin is shown in Figure 3.5. A complete listing of the estimated instream flows throughout the Basin is in Appendix VI.

Figure 3.5
Example Application of Tessmann Method



The Tessmann method is particularly suitable for fish since the seasonal progression of recommended flows resembles the flow regime that fish and other aquatic life are accustomed to under unregulated flow regimes. For example, the recommended spring flows remain relatively high to allow spawning migrations and reproduction to occur and late spring-early summer flows decline slowly to allow downstream migration of young-of-the-year fish. This is particularly important for a system such as the Upper Assiniboine River Basin where intermittent streams provide important spawning and rearing habitat.

(4) Suitability of Tessmann Method for the Upper Assiniboine River Basin

▸ Walleye and White Sucker Spawning

Several field checks were made to confirm the suitability of the method to the Upper Assiniboine River Basin. Four locations on the Assiniboine River were observed during the open water season of 1997 and 1998. On each occasion, a qualitative judgement was made respecting the suitability of the habitat for spawning by walleye and white suckers at that particular flow. At two locations, white suckers were observed spawning during the site visit. The approximate discharge on each observation day was later determined from nearby gauging stations. Discharges on those days when flows were judged to provide suitable conditions for spawning were compared to discharges recommended by the Tessmann method for the spring period. In all cases, observed flows that were deemed suitable for spawning were similar to or less than the flows that would result from applying the Tessmann method. That is, the Tessmann method consistently recommended sufficient or more than sufficient flows for spring spawning by walleye and white suckers.

▸ Northern Pike Spawning

Two locations on Yorkton Creek were observed to determine if the Tessmann method recommended adequate flows for spawning by northern pike. Northern pike had been captured in Yorkton Creek in the spring of 1997 and hay flats adjacent to the creek in several locations appeared to provide suitable habitat for northern pike spawning. Two locations were observed in 1997 and 1998. In April of 1997, the creek was flooded over its banks in several locations, providing good spawning habitat for pike. Discharge on the date observed was 16.3 m^3/s which is about 32 times the mean annual flow. In 1998, the creek was contained well below the banks and no suitable pike spawning habitat existed. Discharge on the date observed in 1998 was 0.414 m^3/s which was about 80 percent of mean annual flow. These observations suggest that flows at a magnitude of several times the mean annual flow are required to provide suitable spawning conditions for pike. However, additional observations at several locations under various flow conditions would be required to determine an achievable flow recommendation that would provide suitable pike spawning conditions.

▸ Channel Maintenance

The Tessmann method provides for channel maintenance by recommending a flushing flow of 200 percent of mean annual flow over a two week period each spring. This flow may not be sufficient for maintenance of stream channels in the Upper Assiniboine River Basin. For the Assiniboine River at Sturgis, a flushing flow of 200 percent MAF as recommended by Tessmann would be approximately 3.25 m^3/s. However, backfill or channel maintenance flows tend to occur around the 1:2 flood frequency (Gordon *et al.* 1992, Newbury and Gaboury 1993). The 1:2 flood frequency at this location is approximately 22 m^3/s (Bart Oegema, Sask Water, pers.

comm.) or about 800 percent of mean annual flow. Similarly, the 1:2 flood frequency for Yorkton Creek near Ebenezer is about 11m^3/s (Bart Oegema, Sask Water, pers. comm.). This value is approximately 2100 percent of the mean annual flow. The Tessmann method recommends a channel maintenance flow of only one m^3/s at this location. A greater percentage of the MAF than is recommended by the Tessmann method is likely required for stream channel maintenance. Additional observations of backfill flows for streams in the Upper Assiniboine River Basin are required before an accurate estimate of channel maintenance flows can be made.

The Tessmann modification of the Tennant method provides good estimates of the flows needed for spring spawning by walleye and white suckers in the Basin. The method likely provides good estimates of flows needed for maintaining fish over the summer and winter periods since it requires that existing natural flows be provided during these low flow months. Adjustments to the method are needed to allow accurate recommendations for channel maintenance flows and for suitable flows for pike spawning. Additional field observations are required before these refinements can be made. In the meantime, the Tessmann method may be used in its unmodified form for general planning purposes in the Basin. However, where development proposals have the potential to store or divert water to the point that the minimum instream flow recommendations would be approached, more detailed, site specific studies should be conducted.

3.4.2.3 Instream Flow Needs Analysis

The Tessmann method was applied to hydrological records from 23 sites in the Upper Assiniboine River Basin (Appendix VI). The results provide a preliminary estimate of minimum required flows for the protection of fish populations in streams of the Basin.

The method was applied to each stream on a monthly basis except for the outlets of Fishing Lake and Good Spirit Lake. No instream flow recommendations were made for these locations. At these sites, stream flows are governed by lake levels. Water spills occur at the outlets on an irregular basis, dependent on water elevations in the lakes. In this situation, it is impractical to require an instream flow since the water is frequently not available. Further, with only infrequent spills, there are no downstream aquatic communities dependent on regular flows.

Application of the Tessmann flushing, or channel maintenance flow recommendation is problematic for many of the streams. When the Tessmann method is applied to streams having relatively little monthly variation in flows, the flushing flow recommendation provides a period of significantly higher flows for channel maintenance. However, many of the streams in this Basin are characterized by a short period of high spring flows with low flows for most of the remainder of the year. Consequently, the mean annual flow, on which the flushing flow calculation is based, is low in comparison to the mean monthly flow in April or May. When the Tessmann recommendation of 200 percent of MAF is applied to the streams of the Basin, the flushing flow recommendation for 12 locations is less than the flow that is otherwise recommended for the month of greatest flow (i.e. 200 percent MAF is less than 40 percent MMF). These locations are mainly in Saskatchewan, upstream of Lake of the Prairies. For these locations, the two week calculated flushing flow period would be ineffective and is therefore not recommended.

The Shell River and the Assiniboine River downstream of Lake of the Prairies have less seasonal variation in their hydrographs. Consequently, the Tessmann method results in significantly higher flushing flow recommendations, between 25 and 67 percent higher than the otherwise recommended monthly flows for April or May. These recommended flows should be effective in maintaining channel form. For these locations, provision of the additional flushing flow is recommended.

Several of the sites listed in Appendix VI are located downstream of water control structures with reservoirs. The existence of a reservoir can provide flexibility for water managers to provide the recommended flow volumes at downstream locations. However, problems may arise if instream flows are required without consideration for reservoir operations. Strict adherence to recommended instream flow values may result in extreme fluctuations of reservoir elevations beyond the desirable operating range. This may be a particular problem for the Lake of the Prairies if recommended instream flows are provided downstream of that location. These fluctuations may also be harmful to the fish populations resident in the reservoirs. It must be emphasized that the instream flow recommendations in Appendix VI are a 'first cut' only and that further analysis will be required before finalizing instream flow recommendations. Some compromises will be necessary to allow reasonable flows downstream of the reservoirs while maintaining suitable conditions for reservoir fish populations.

3.4.3 Other Instream Uses

On-site uses include those activities in which water is necessary or desirable, yet no significant water is withdrawn. These uses are typically recreational, such as boating, swimming, sportfishing, wildlife needs, camping, etc., and are not easily quantified. An inventory of the various water bodies in the Basin was prepared and the recreational uses were initially identified, then submitted to the members of the Local Watershed Committees for their review. The final inventory of recreational water uses is shown in Table 3.25 for Saskatchewan and Table 3.26 for Manitoba.

Table 3.25 - Saskatchewan Recreation Demands

Water Body	Fishing	Boating / Canoeing	Camping	Contact (swimming)	Wildlife	Other
Annie Laurie Lake	X	X	X	X	X	
Crescent Lake					X	
Crystal Lake	X	X	X	X	X	Cottages
Dog Lake					X	
Echo Lake					X	
Fishing Lake	X	X	X	X	X	Cottages Regional Park
From Lake		X				
Good Spirit Lake	X	X	X	X	X	Cottages Prov. Park
Hazel Lake		X				
Hedley Lake					X	
Horseshoe Lake					X	
Kornitski Lake	X	X				
Lady Lake	X	X	X	X		Cottages Regional Park
Leech Lake					X	
Little Boggy Creek	X	X				
Loch Lomond	X				X	
Margo Lake	X	X			X	
McQuat Lake	X	X			X	
Melville Reservoir	X	X			X	
Nelson Lake	X	X	X	X	X	Cottages
Newburn Lake		X			X	
Rousay Lake					X	
Sakwasew Lake					X	
Saline Lake					X	
Salt Lake					X	
Sheho Lake					X	

Table 3.25 - Saskatchewan Recreation Demands (continued)

Water Body	Fishing	Boating / Canoeing	Camping	Contact (swimming)	Wildlife	Other
Shutte Lake		X				
Silver Lake					X	
Stonewall Lake					X	
Theodore Reservoir	X	X	X	X	X	
Ussineskaw Lake		X				
Whitesand Lake		X		X		Cottages
Wilson Lake	X	X				
Woody Lake	X				X	
Assiniboine River above Kamsack	X	X	X	X	X	
Assiniboine River above Sturgis	X	X	X	X	X	
Assiniboine River above Shellmouth	X	X	X	X	X	
Conjuring Creek	X					
Crooked Hill Creek					X	
Cussed Creek					X	
Goodspirit Creek	X				X	
Kop Creek	X					
Lillian River	X					
Robinson Creek	X					
Sorefoot Creek					X	
Whitesand River	X	X	X		X	
Willow Brook					X	
Yorkton Creek					X	

Table 3.26 - Manitoba Recreation Demands

Water Body	Fishing	Boating / Canoeing	Camping	Contact (swimming)	Other
Assiniboine River	X	X			
Gopher Creek	X		X		
Bosshill Creek	X				
Scallion Creek	X				
Beaver Creek	X				
Snake Creek		X			
Deerhorn Creek	X				
Silver Creek	X				
Silver Beach Lake	X	X			
Little McBride Lake	X	X			
Verrall Lake	X				
Shilliday Lake	X				
Line Lake	X				
Beaver Lake	X				
Mossberry Lake	X				
Wellman/Glad Lake	X	X	X	X	Cottages/Resort
Two Mile Lake	X				
East/West Blue	X	X	X	X	
Child's Lake	X	X	X	X	Cottages/Resort
Laurie Lake	X	X			
Gull Lake	X	X			
Perch Lake	X	X			
Shell River	X	X			
Big Boggy Creek	X				
Lake of the Prairies	X	X	X	X	Cottages/Resort
Goose Lakes	X	X	X	X	
Beautiful Lake	X	X			
Spear Lake (Russell Reservoir)	X				

4 Methods of Supply vs. Use Analysis

When examining the status of water supply and use in the Upper Assiniboine River Basin, it is necessary to investigate how well the uses are being satisfied and the dependability of the supply. Because of the complex relationship between the two, there is no certain method to compare water supplies and water use. The two questions which must be addressed are: how will supply and use be analyzed, and what time and spatial scales will be used.

Supply and use are not mutually exclusive, meaning that the uses will develop according to the supply that is available. Furthermore, there are varying degrees of water shortages. A certain amount of judgement is involved in defining what is an acceptable shortage, which in turn is a function of the type of use. For example, with municipal water supply requirements, 100 percent availability is desired, whereas for irrigation in Saskatchewan a 70 percent (i.e., 7 years out of 10) supply is deemed acceptable. The addition of infrastructure (reservoirs, pipelines, treatment facilities, etc.) can drastically change the supply and use relationship. Comparing the water supply to the water use in any basin is complex because of the many variables and levels of judgement involved.

The approach taken in this Study is to look at the uses that have developed in the Basin (the present uses) and then look at how often there are supply shortages. This requires a judgement on what is an acceptable level of shortage for the use. This means there is a supply problem when a particular use is not satisfied to an acceptable level an acceptable proportion of the time.

How well a water use appears to be satisfied is also a function of the time period used and the spatial scale of reference. For example, we may know the volume that flows in the Assiniboine River at a particular location (e.g., at the confluence with the Qu'Appelle River) but not how this flow relates to a particular use upstream (e.g., the municipal use of Kamsack). Also, we may know the annual volume of water that flowed through a particular point in any given year, but not know if that flow is sufficient during a low flow winter month.

The time and spatial scales used when examining water supply and use depend on the detail of analysis needed, the amount of data available and the resources available to analyze the data. The data and resources required increase exponentially with the detail or complexity of analysis that is used. For surface water, the data and resources available were sufficient to look at the supply vs. use on a monthly volume basis in time and dividing the Basin into 21 watersheds spatially. For groundwater, the available data and the supply/use relationship differ. Therefore, the same analyses could not be conducted. Details on the surface water and groundwater analyses follow.

4.1 Surface Water

4.1.1 Approach

Two approaches are used in this analysis to examine water supply and use. A simple method is used to investigate the water supply in the Basin as a whole and how it compares to the overall Basin use. A more detailed analysis is also provided, as it is warranted for a basin of this magnitude and a study of this complexity.

Perhaps the simplest method of comparing water supply and water use in a watershed is to compare the estimated annual water use volumes to annual flow volumes for the entire Basin. This would provide a very simple indication of how the water use compares to flow volumes available. Median annual natural flows for the Assiniboine River at the confluence with the Qu'Appelle River were compared to water use estimates and are discussed in Chapter 5.1.

Water supply and use is extremely variable, therefore a more detailed analysis was needed that examined how well supply meets use in time and space, i.e., depending on the location in the Basin and whether or not a drought may be occurring. The water supply analysis provided mean monthly flows for 21 watersheds over the historical period of 1941-1995 inclusive. Although the 1930s are thought to be drier, analysis of that period was limited by the available hydrometric data. Time and spatial scales of this nature are adequate for basin planning exercises and hence for this Study. If specific projects are proposed, detailed and site specific analysis is required for both water supply and water quality.

The basic principle of this analysis is to look at the water uses for each month over the historical period to see if enough water was available, i.e., assuming that the current level of development was in place over the historical period. The water availability is a function of the supply and infrastructure to store and move the water. Statements can then be made as to how well any given use would have been supplied in the past. If past conditions are representative of future conditions, statements can also be made as to how additional uses will be supplied in the future.

Such an analysis must take into account the water supply, the water uses and nature and physical constraints of the infrastructure involved in making water available, and the water management policy. This infrastructure includes such physical works as dams and reservoirs, pipelines, channels, etc., while policy outlines the rules of reservoir operation and the priorities of use.

4.1.2 Water Management Model

The basic premise of the surface water management model is presented here. A detailed presentation of the components and performance can be found in Appendix VII.

(1) Principle

When dealing with a complex system, such as the Upper Assiniboine River Basin, with many watersheds, uses, reservoirs, etc., tracking flows throughout the Basin can become complex. Therefore, a computer model is used to perform the calculations. The model used in this analysis is the Water Resources Management Model (WRMM) developed by Alberta Environment as the primary tool for the South Saskatchewan River Basin Planning Program. The model was developed as a planning tool for water resources utilization, the river basin being the fundamental unit of study.

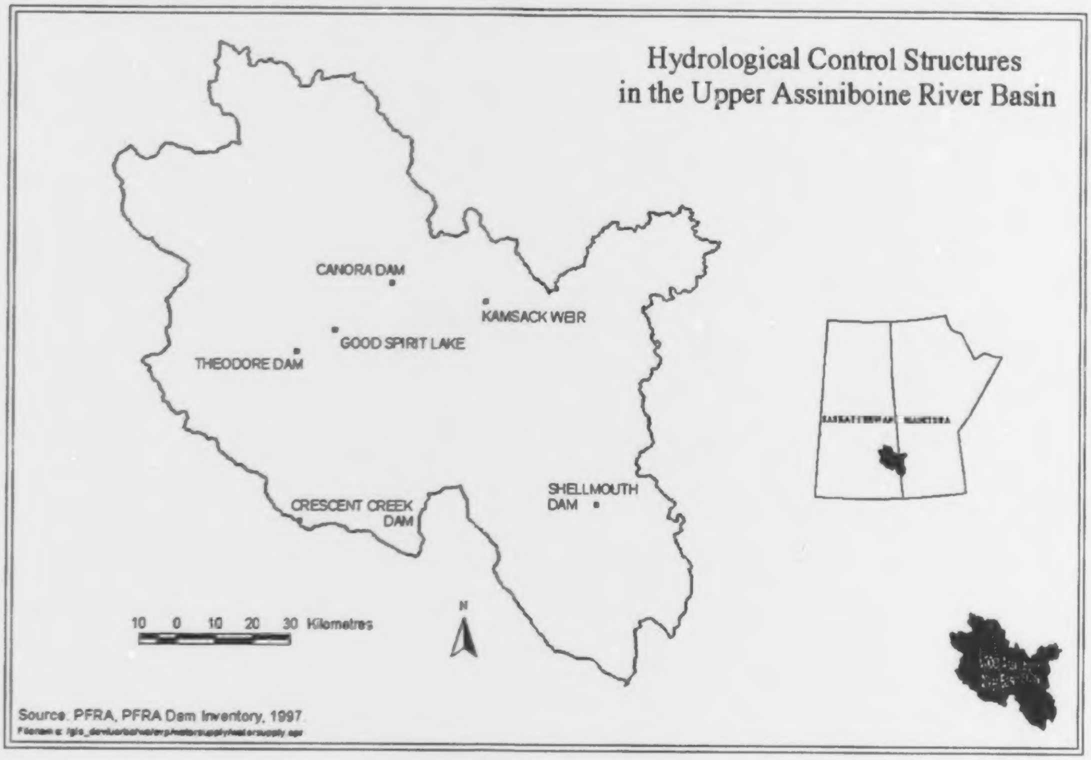
The model routes the estimated monthly natural flows through the system according to the physical layout, the infrastructure present (recognizing the physical limits of that infrastructure), uses and losses from the system, and the rules put in place for priority of use and operation of infrastructure. Simulations are performed on a monthly time step over the assigned period of record. It allocates the available water supply to the withdrawal and instream uses in the basin based on a priority basis (the policy dimension). Planning is facilitated by allowing for the effect on any component(s) of the system resulting from the change of any other component(s) of the system to be examined.

The simulation was run on monthly time steps over the period of record of natural flows, i.e., 1941 to 1995, representing 660 consecutive months of flows. Within this time frame, periods of both low and high flows occur, thus it is thought to be reasonably representative of the variability possible in the system.

(2) Layout and Components

The Upper Assiniboine River Basin WRMM model is actually comprised of three individual WRMM models, the main Assiniboine River model, a Fishing Lake model developed for another study, and a Yorkton Creek model also developed for another study. Figure 4.1 shows the locations of the major control structures of interest, while Figures 4.2 and 4.3 show the layout of the watersheds and models schematically. Table 4.1 lists the types and numbers of various components in the models. The main model has 23 watersheds, five reservoirs, and 35 major water uses.

Figure 4.1
Major Hydrological Control Structures in the Upper Assiniboine River Basin


Hydrological Control Structures
in the Upper Assiniboine River Basin
CANORA DAM
KAMSACK WEIR
GOOD SPIRIT LAKE
THEODORE DAM
SHELLMOUTH DAM
CRESCENT CREEK DAM
10 0 10 20 30 Kilometres
N
SASKATCHEWAN
MANITOBA

Source: PFRA, PFRA Dam Inventory, 1997

Figure 4.2
Schematic Diagram for Main Model

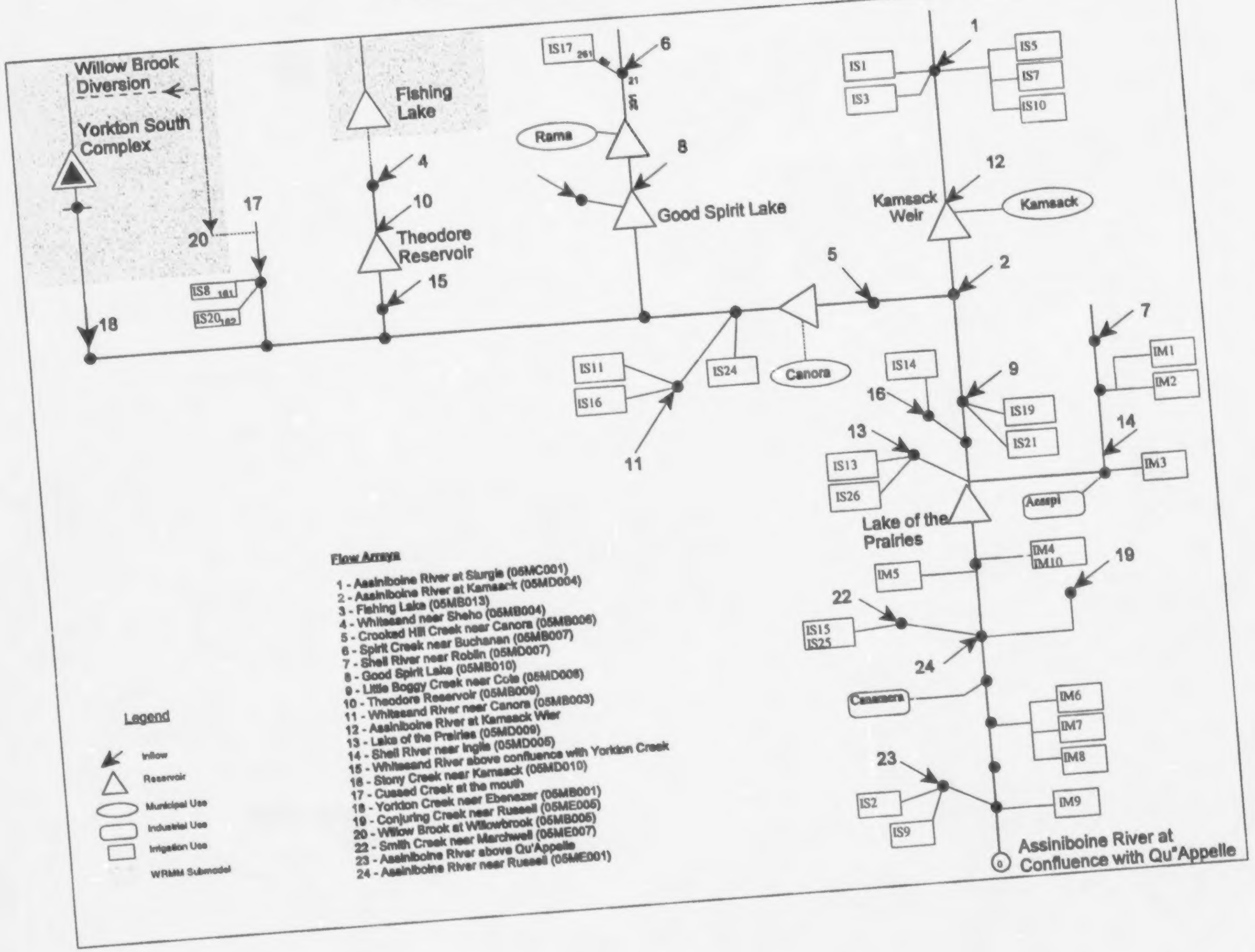
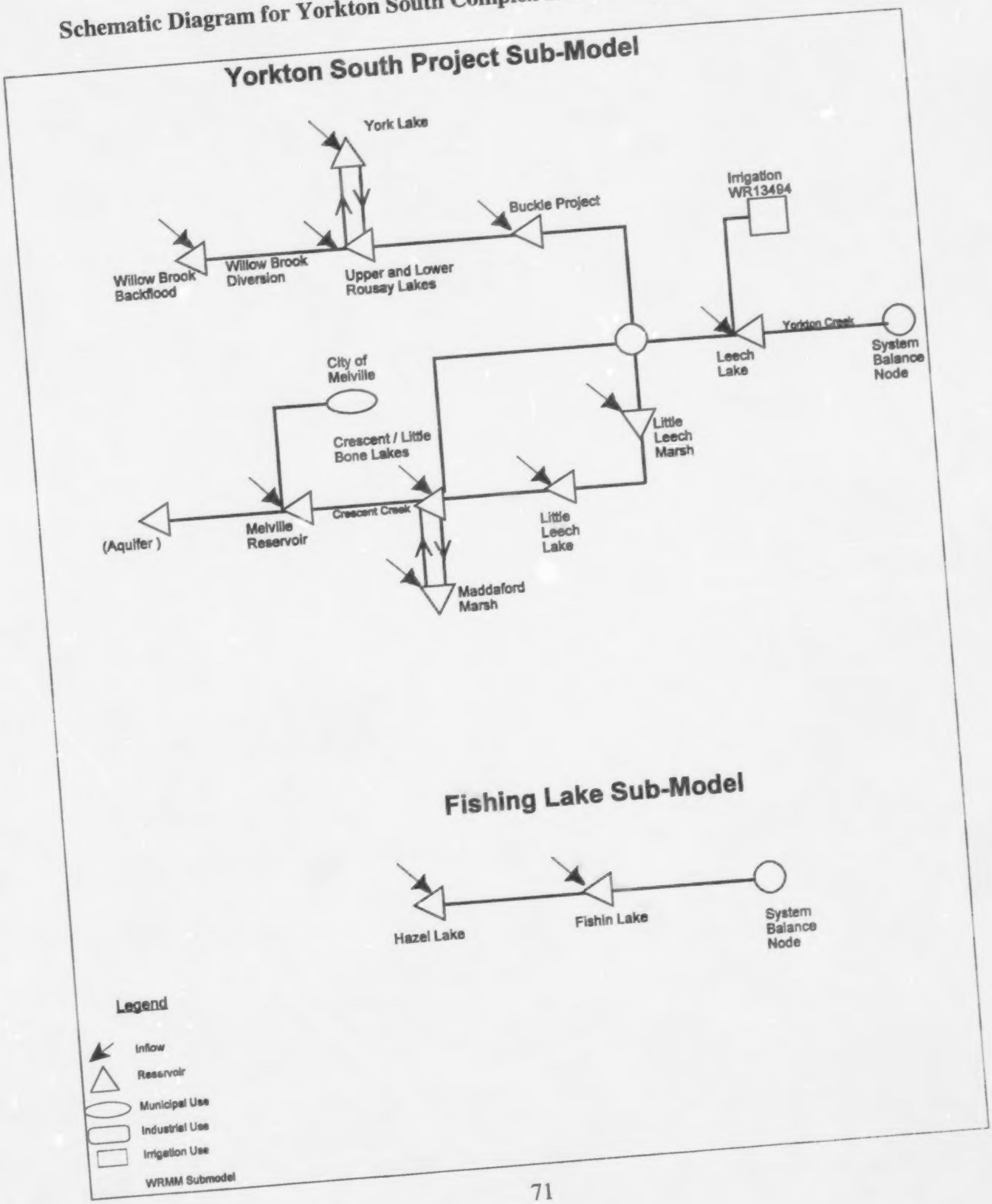

Willow Brook Diversion
Yorkton South Complex
Fishing Lake
Theodore Reservoir
Rama
Good Spirit Lake
Kamsack Weir
Kamsack
Canora
Lake of the Prairies
Assopi
Canamera
Assiniboine River at Confluence with Qu'Appelle
IS1
IS3
IS5
IS7
IS10
IS8 181
IS20 182
IS17 261
IS11
IS16
IS24
IS14
IS19
IS21
IS13
IS26
IS15
IS25
IS2
IS9
IM1
IM2
IM3
IM4
IM10
IM5
IM6
IM7
IM8
IM9
1
2
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Flow Arrays
1 - Assiniboine River at Sturgis (05MC001)
2 - Assiniboine River at Kamsack (05MD004)
3 - Fishing Lake (05MB013)
4 - Whitesand near Sheho (05MB004)
5 - Crooked Hill Creek near Canora (05MB006)
6 - Spirit Creek near Buchanan (05MB007)
7 - Shell River near Roblin (05MD007)
8 - Good Spirit Lake (05MB010)
9 - Little Boggy Creek near Cote (05MD006)
10 - Theodore Reservoir (05MB009)
11 - Whitesand River near Canora (05MB003)
12 - Assiniboine River at Kamsack Wier
13 - Lake of the Prairies (05MD009)
14 - Shell River near Inglis (05MD005)
15 - Whitesand River above confluence with Yorkton Creek
16 - Stony Creek near Kamsack (05MD010)
17 - Cussed Creek at the mouth
18 - Yorkton Creek near Ebenezer (05MB001)
19 - Conjuring Creek near Russell (05ME005)
20 - Willow Brook at Willowbrook (05MB005)
22 - Smith Creek near Marchwell (05ME007)
23 - Assiniboine River above Qu'Appelle
24 - Assiniboine River near Russell (05ME001)
Legend
Inflow
Reservoir
Municipal Use
Industrial Use
Irrigation Use
WRMM Submodel

Figure 4.3
Schematic Diagram for Yorkton South Complex and Fishing Lake Sub-models


Yorkton South Project Sub-Model
York Lake
Irrigation WR13494
Buckle Project
Willow Brook Backflood
Willow Brook Diversion
Upper and Lower Rousay Lakes
Yorkton Creek
Leech Lake
System Balance Node
City of Melville
Little Leech Marsh
Crescent / Little Bone Lakes
Crescent Creek
(Aquifer)
Melville Reservoir
Little Leech Lake
Maddaford Marsh
Fishing Lake Sub-Model
Hazel Lake
Fishin Lake
System Balance Node
Legend
Inflow
Reservoir
Municipal Use
Industrial Use
Irrigation Use
WRMM Submodel

The Fishing Lake sub-model was built strictly for the Fishing Lake watershed and immediate area as part of a study on the lake (Sask Water 1999). That study demonstrated that the lake has not spilled in the period of record for this Study, therefore the watershed has no effect on the rest of the Basin and hence the main model of the Upper Assiniboine River Basin. However, as the watershed is within this Basin the model is included in the overall schematic to illustrate that it has been addressed.

The Yorkton South Complex represents most of the Yorkton Creek near Ebenezer watershed, and is comprised of 10 watersheds and 10 reservoirs. The complete details of the setup, inputs and output for all the models are included in Appendix VII, however the highlights are included here.

Table 4.1 - Summary of Model Components

Model	Reservoirs	Inflow Nodes	Number of Major Uses		
			Municipal	Industrial	Irrigation
Yorkton South Complex	10	11	1	0	1
Fishing Lake	2	2	0	0	0
Upper Assiniboine River (Main model)	6	24	3	2	28
Totals	18	37	4	2	29

(3) Inputs and Sources of Data

The data needed to run the model includes:

- Physical data (reservoir capacities, etc.);
- Water supply (inflows);
- Water uses;
- Water losses (evaporation, etc.); and
- Operating rules.

4.1.2.1 Model Physical Data

Physical data, including reservoir area and capacity curves, pump capacities and control structure rating curves are readily available in the offices of the various participating water management agencies.

4.1.2.2 Model Water Supply

The water supply for the main model consists of a number of components. The estimated natural flow arrays for 20 of the 21 watersheds as calculated in Chapter 2.1 comprise the majority of the Basin inflow. A special case exists when handling the inflow from the Yorkton Creek near Ebenezer watershed because of the Yorkton South Complex sub-model. The inflow from the watershed was adjusted for the present water use and for the effects of the Yorkton South Complex using the sub-model before being used in the main model. For the natural flow case, the inflow array as explained in Chapter 2.1 was used. Groundwater inflows were included in the Yorkton South Complex model for the City of Melville supply and in the main model as inflow estimates into Good Spirit Lake.

4.1.2.3 Model Uses

The water uses considered necessary for input into the model consisted of those only within the effective drainage area and considered of significant enough size to affect downstream flows or needed for the purpose of demonstration. The uses were limited to the effective drainage area to keep the number of uses more manageable. This was considered acceptable because in the case of water supply, the concern is with years of median or lower annual volumes and in particular drought years. Projects located in the gross drainage area by definition do not affect downstream users in years of median or lower runoff volumes. The net effect is that projects in the gross drainage area generally do not have a significant effect on downstream supply in drought years, therefore they can be ignored within the context of this analysis.

All municipal and industrial surface water withdrawals were included in the model. Wildlife conservation projects were not included mainly because of their large number and the resources which would be necessary to include them in the model for what is thought to be only limited benefit. Many are in the gross drainage area of the Basin and the net effect on annual flow years is expected to be negligible.

Agricultural uses were limited to irrigation withdrawals of greater than 25 dam^3/y, arbitrarily chosen as a cutoff point but low enough to ensure that even projects of that size have a negligible effect on water supplies anywhere downstream in the Basin. Rural domestic surface water uses (i.e., dugouts) and livestock and crop spraying uses (dugouts and wetlands) were also not included for the following four reasons. First, it did not warrant the large amount of work and cost needed to take datasets of dugout location and size and incorporate them into the model. Second, the number and location of natural water bodies used as dugouts is unknown. Third, uses from small, manmade structures within the effective drainage area are expected to be relatively small when compared to total use figures. Evidence supporting this assumption can be found in the natural flow study (Prairie Provinces Water Board 1980). Fourth, these uses were not accounted for when the natural flow arrays were developed, therefore to some extent they are indirectly accounted for through a reduction in the supply.

The result is that the effort necessary to include uses out of dugouts and not in the effective drainage area in the model was not justified given the marginal benefits.

4.1.2.4 Model Losses

Evaporative losses from the various reservoirs were estimated for each month of the simulation by the model. The model calculates the evaporation volume in each defined reservoir using the net evaporation depth (gross evaporation less precipitation) and the reservoir surface area at the end of the month.

4.1.2.5 System Operating Rules

The operating rules used for the system depend on the scenario being modelled. Some policies are unique to each model scenario and are discussed in the chapter on model runs. The operating rules common to all scenarios, beginning at the headwaters and working downstream, are briefly outlined below. Very obvious operating rules are basic to the system (e.g., water is not released from Good Spirit Lake to support channel flows below Shellmouth Dam) and are not discussed. While all policies may not precisely imitate the operation of individual units, the combined result of the various policies reflects the current overall operation of the Basin.

(1) Yorkton South Complex / Willow Brook Diversion

In general, runoff is held within the Yorkton South Complex for use in the various reservoirs. Spill from the system is held as surcharge (unless the maximum surcharge limit is reached) in reservoirs until the peak flow in Yorkton Creek has passed the City of Yorkton. Water held in surcharge is then released as quickly as possible without causing downsteam flooding.

(2) Willow Brook Diversion

The diversion is actually a backflood irrigation and diversion scheme. Runoff first fills the backflood irrigation project, then spills into the diversion channel to the Yorkton South Complex. Any spill larger than channel capacity continues down the natural Willow Brook channel to Cussed Creek.

(3) Theodore Reservoir

The reservoir is used primarily for flood protection. It was used to supplement the Town of Canora water supply before the town converted to a groundwater source. The reservoir is drawn down in the fall for flood storage.

(4) Good Spirit Lake

The structure is operated to minimize overbank flows on the Whitesand and Assiniboine Rivers during flood events, and to provide optimal recreation water levels in the lake for the June to September period. The reservoir is drawn down in the fall for flood storage.

(5) Canora and Kamsack Weirs

The two reservoirs resulting from the weirs at Canora and Kamsack are essentially run of the river reservoirs with fixed weirs and spill elevations.

(6) Lake of the Prairies

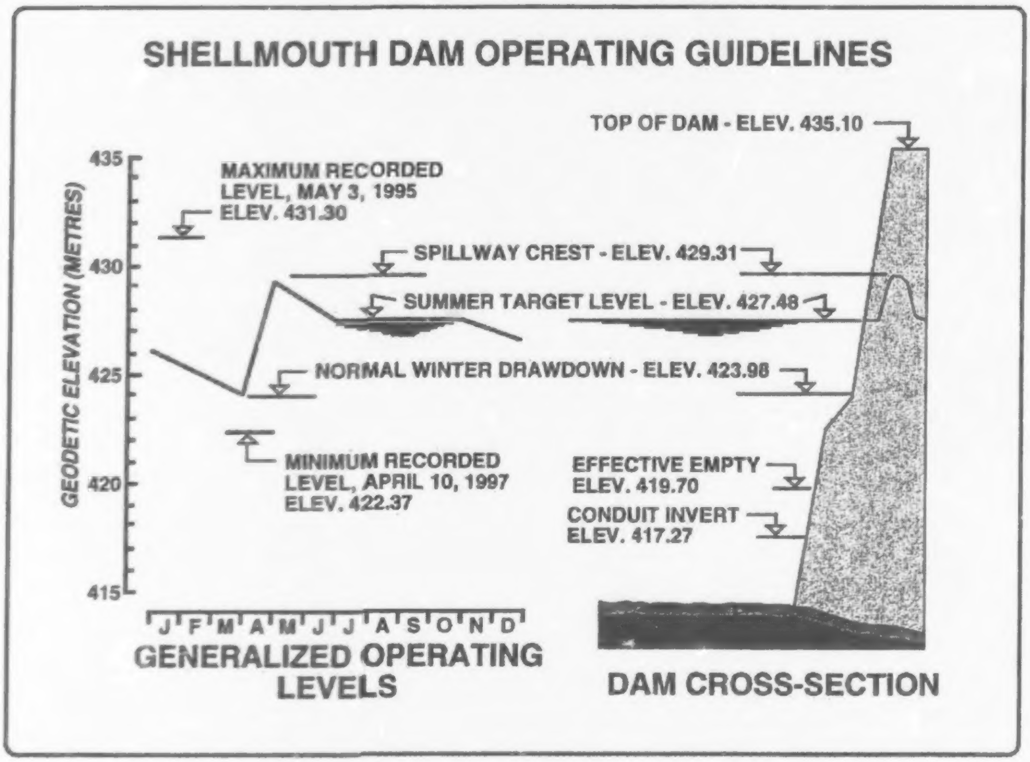
The general operating guidelines that have been developed to ensure that the Lake of the Prairies can provide reasonable levels of both flood protection and water supply capability are indicated on Figure 4.4. Details of the Lake of the Prairies Operating Guidelines are provided in Appendix VIII. In general, the reservoir is gradually lowered over the fall and winter period to provide flood storage capacity for the spring runoff which usually begins around the end of March. The winter drawdown target level is somewhat variable, dependent upon the spring inflow forecast, either to increase flood storage capacity or to increase the likelihood that the available runoff will provide sufficient storage for water supply and recreational use during the summer period.

During spring runoff, the primary consideration is to control outflows to minimize downstream flooding. The intent is to minimize overbank flooding along the river below the dam and during flood periods to keep outflows to a value no greater than what the river flow would have been without the dam in place. An attempt is made to maintain outflows to a maximum of about 45 m^3/s to prevent localized flooding immediately downstream of the dam and to facilitate land drainage.

During normal summer operation, the primary consideration is to make releases to meet water allocation commitments to downstream licensed users, for domestic users and to meet instream flow needs. Release rates are varied throughout the year to meet a minimum target instream flow of 0.7 m^3/s immediately below the dam and 5.6 m^3/s at Headingley. Consideration must also be given to other factors such as travel time of Lake of the Prairies releases and maintaining an adequate lake level for recreational and fishery purposes.

The WRMM model, based on historical data, does not sufficiently incorporate forecasting based on operation of reservoirs. Thus the operation of Shellmouth Dam was simplified in the model to draw the lake down to 425 m in the fall and aim for a summer operating level of 429.92 m. The basic target elevations were combined with downstream uses and release rate restrictions of 45 m^3/s where possible and a minimum downstream flow of 0.7 m^3/s. Although this does not precisely imitate the forecast-based operation of Shellmouth Dam, it is sufficient for a general planning tool based on mean monthly flows over an historical period. Any proposed operational adjustment would require study at a suitable level of detail and complexity. The model can simulate water releases for industrial users, irrigation, downstream flow maintenance, and water held within the reservoir for recreation and flood control.

Figure 4.4
Simplified Lake of the Prairie Operation Guidelines


SHELLMOUTH DAM OPERATING GUIDELINES
TOP OF DAM - ELEV. 435.10
MAXIMUM RECORDED LEVEL, MAY 3, 1995 ELEV. 431.30
SPILLWAY CREST - ELEV. 429.31
SUMMER TARGET LEVEL - ELEV. 427.48
NORMAL WINTER DRAWDOWN - ELEV. 423.98
MINIMUM RECORDED LEVEL, APRIL 10, 1997 ELEV. 422.37
EFFECTIVE EMPTY ELEV. 419.70
CONDUIT INVERT ELEV. 417.27
GEODETIC ELEVATION (METRES)
435
430
425
420
415
J F M A M J J A S O N D
GENERALIZED OPERATING LEVELS
DAM CROSS-SECTION

(7) Water Uses

Priorities are established for water use in the Basin during periods of water shortage. Although a formal written policy has not been adopted, water use priority in the Basin has historically reflected that of other areas throughout Saskatchewan and Manitoba and tends toward limiting the social and economic impacts of water shortages inasmuch as controls and policy allow. Generally, the priority in the Upper Assiniboine River Basin in descending order of is to first satisfy municipal uses, then irrigation and/or industrial uses, then hold water in reservoirs for recreational and aquatic life purposes, or released to maintain channel flows or downstream demand. The model to simulate present conditions was designed to reflect that hierarchy.

The model manages competing water uses on a priority basis and allows for the stepped reduction of water uses to simulate the sharing of impacts between various water uses. In a general sense in the model, municipal uses receive the highest priority, followed by industrial uses, irrigation, maintenance of flows below Shellmouth and finally recreation within the reservoirs. However, depending on the location within the Basin, and the demands present, these priorities may vary slightly.

Municipal water uses receive the highest priority. In instances of extreme drought the model was set to provide 90 percent of the desired use. Similarly, industrial uses also were allotted a high priority, with a similar 10 percent reduction in times of severe drought. This reflects the fact that there are very few industrial users using a relatively small amount of water.

Irrigation uses are managed somewhat differently in the model. Uses in the headwaters above the reservoirs receive the highest priority, to simulate the fact that if water is available in the headwaters it is withdrawn prior to reaching any reservoirs. Uses along the main river stems in Saskatchewan receive second priority after municipal uses. Finally, irrigation below the Shellmouth Dam receives the highest priority, although it will be stepped down by a maximum of 10 percent to help maintain the one industrial user below the dam or to maintain reservoir levels if it is suffering a shortage or if channel flows are below 1.42 m^3/s.

(8) Channel and Downstream (Off-basin) Demand

For the purpose of the model, downstream demands consist of both apportionment and water demands in Manitoba below the confluence of the Assiniboine and Qu'Appelle rivers. The main model only lists channel flow as a demand for the stretch of the Assiniboine River from the Shellmouth Dam to the confluence with the Qu'Appelle River. Water will be withdrawn from Lake of the Prairies to maintain a minimum channel flow of 1.42 m^3/s once the withdrawal uses have been supplied. In periods of flooding, water is held within the flood surcharge of the dam to limit channel flow to 1600 cfs when possible.

4.1.2.6 Model Calibration Run

The model was run to check its performance vs. key recorded flows and water levels. In that run, the model was configured and operated to reflect the current conditions as if they were present over the historical period. The performance of the model was judged by how well it simulated reservoir levels (particularly Lake of the Prairies) and recorded flows at specific gauging stations in light of the changes to infrastructure, operating policies and water use over time. The period of primary focus was post-1969, as this is the time in which the major infrastructure was all in place.

This type of an approach is not an ideal calibration test. However, this run represents a reasonable check of how well the model performs based on the data available. Appendix VII contains a detailed description of the calibration run and analysis and discussion of the results.

It is concluded from that analysis that the model sufficiently reflects historical data for the purpose of this Study, namely as a regional planning tool.

4.1.2.7 Model Runs and Output

The model was run over the period of record for a number of scenarios. In each scenario, the model looks at how the system performs had the prescribed infrastructure and uses been present over the entire historical period. The scenarios modelled were:

Simulated Natural Flows - effects of infrastructure (reservoirs, diversions, etc.) and uses removed;

- Current Conditions - current levels of infrastructure and use; and
- Future Water Use Conditions - incorporates predicted use increases.

Demonstration runs were:

- Operation of Theodore Reservoir for fisheries instream flow priority;
- Operation of Lake of the Prairies for fisheries instream flow priority; and
- Effect of latest new user (Asessippi Ski Hill) on downstream conditions.

The results for all runs are presented and discussed in Chapter 5. Output is provided in the graphical presentation of water levels or mean monthly flows of appropriate reservoirs and river reaches.

4.2 Groundwater

Examining groundwater supply and use is fundamentally different than surface water supply and use. First, most if not all groundwater uses are withdrawal uses. These uses have also developed where the supply has proven sufficient, or else have adjusted to the available supply. Second, groundwater supplies are usually less susceptible to short term, extreme changes in the hydrological cycle (i.e., floods and droughts) providing more warning time to adapt to any changes in the supply. Finally, the data that is available to analyze the performance of a water supply (aquifer) generally does not exist, is difficult to obtain, is suspect in quality, or the resources for detailed analyses of the data are not available.

Performance of groundwater supplies can only be assessed with sufficient data. These data include adequate borehole data to delineate an aquifer and assess the geology and hydrogeology, and sufficient hydraulic data to illustrate water levels, responses to pumping and water level recovery characteristics.

The net result is that the performance of many groundwater supplies is not known, other than to say that there have been few problems to date, but their susceptibility to depletion is not completely known. However, as the time scales are most often much longer than with surface water, problems with supply will usually be relatively slower in developing, providing some warning that a supply problem is imminent.

A more pro-active management approach is used where warranted, such as with the City of Yorkton aquifers , where much more data are obtained. In instances such as this, basic technical procedures can be used to estimate the ability of an aquifer to sustain a particular use. These methods and results are discussed in Chapter 5.2.

5 State of Supply vs. Use

5.1 Surface Water

The analysis of the state of supply and use begins with some very simple comparisons on a mean annual basis at the outlet, then proceeds to look at more complicated comparisons in time and space (i.e., on a monthly basis and at other points in the Basin). Relationships between supply and use are investigated for current conditions but also discussed is the suspected future water use as compared to the supply in a basin. Finally, some specific model runs are conducted to illustrate the effect of a new user on the water supply and other users, and to investigate the effect of operating two reservoirs with more emphasis on achieving desirable instream flows below the reservoirs.

It is first necessary to define some of the concepts which will be discussed. The "natural flows" estimates used in the comparisons are the simulated natural flows, which although they are very similar, they do differ slightly from the natural flows as calculated in Chapter 2 because of the vagaries of modelling and because of the adjustments made for Good Spirit Lake evaporation as discussed in Chapter 3.2.4. However they are used here in order to remove the effect of the modelling process from any differences in natural vs. regulated flows. Appendix VII discusses simulated natural flows in detail.

The "regulated flows" represent the modelled flows after the uses have been removed. For the present use scenario, these are the flows which occur now. The difference is an indirect estimate of water use that actually occurs at any given location in the basin modelled, noted as the "simulated uses" here.

There is also an item related to the "calculated water uses" from Chapter 3 and whether or not wildlife conservation uses should be considered consumptive. To address this circumstance, discussion of both water use totals are included, that is with the wildlife conservation allocations included (at 64,000 dam^3/y) and without (at 45,000 dam^3/y).

Finally, the uses from Chapter 3 include those supplied by groundwater. For most uses, the source type of supply is known, however for a few of the agricultural uses there are no data available which would indicate the proportion of surface water and groundwater sources. In order to facilitate discussion of supply vs. use it is necessary to have an idea of the total surface water use, therefore some assumptions are made as to the water source of these uses. The three types of water use not separated by source are livestock, rural domestic and pesticide spraying. Arguably, livestock and spraying uses can be considered mostly surface water. This assumes that livestock are watered and sprayers loaded mostly from dugouts and sloughs, although wells are undoubtedly used in some cases.

There is less confidence in the estimated proportion of surface water or groundwater used for rural domestic uses. It was assumed that domestic use is supplied primarily by wells, although

F2

undoubtedly dugouts are also used. The total estimated rural domestic use of 1770 dam^3/y is about 3 percent of the total Basin use estimate. Therefore, the error in this assumption is small compared to total uses and the error involved in all the use estimates.

Using the assumptions noted above, Table 5.2 shows the total calculated surface water uses used in further discussions. With all suspected and known groundwater uses removed, the surface water uses are calculated to be approximately 54,000 dam^3/y and 35,000 dam^3/y with and without wildlife conservation allocations respectively. Based on these assumptions, approximately 20 percent of uses are supplied by groundwater, but within that 20 percent is much of the domestic use supplied either through individual systems or through municipal services.

Table 5.1 - Assumed Sources of Undifferentiated Water Uses

Use Type	Calculated Annual Use (dam^3/y)	Percent of Total Use (with and without wildlife conservation projects)		Assumed Source
		with	without	
Livestock	3520	5.5%	7.8%	Surface Water
Domestic	1770	2.8%	3.9%	Groundwater
Spraying	280	0.4%	0.6%	Surface Water
Total	5570	8.7%	12.3%	

Table 5.2 - Total Estimated Surface Water Uses for Discussion Purposes

	Estimated Annual Use of Component (dam^3/y)	Total Annual Water Use (dam^3/y)
Total Water Use in Basin	-----	63940
w/o Known Groundwater Uses	7880	56060
w/o Estimated Groundwater Use	1770	54290
w/o Wildlife Conservation Allocations	19050	35240

5.1.1 Current Conditions

The term "current conditions" refers to a system which reflects the present level of development in the Basin, i.e., the present infrastructure and water uses. Historical flows are routed through the system to examine how the supply would have met the uses had they been in place over the period from 1941-1995.

5.1.1.1Simple Analysis - Assiniboine River at the Outlet

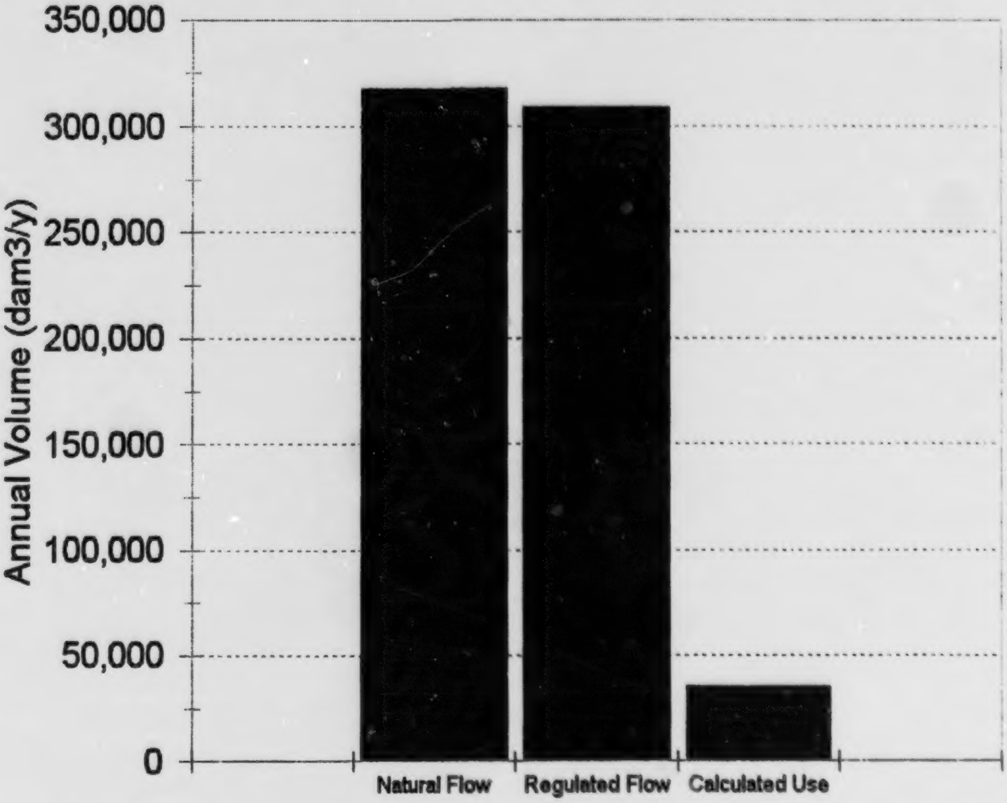
Perhaps the simplest comparison of supply vs. use is to look at flow volumes and water uses for an entire basin in a typical year. This type of simple examination ignores how water supply is distributed in time and space but does provide an indication of how much water is potentially available. Another problem of this approach is defining a typical year, particularly in this Basin because of the relatively short period of record used and the wide variation in annual volumes, especially the 1995 flood. This problem is apparent when the mean and median annual natural flow volumes for the Assiniboine River at the confluence with the Qu'Appelle River are examined, at approximately 430,000 dam^3/y and 320,000 dam^3/y respectively. The median is only 75 percent of the mean, mainly because of the magnitude of the 1995 flood and its skewing effect. It would be logical to use only the median here, except that instream flow needs estimates are based on mean flows and thus when compared to median flows appear exorbitantly large. Therefore, both the mean and median annual natural flow volumes are shown on the appropriate figures.

Figure 5.1 shows the simulated median annual natural and regulated flow volumes for the Assiniboine River above the Qu'Appelle River. The regulated flow volume represents the flow volume from the model after the uses have been addressed. Also shown is the annual surface water use for the entire Basin as estimated in Chapter 3. The difference between the natural flow volume and the regulated flow volume represents the water use as simulated by the model. This difference is approximately 22,000 dam^3/y and is less than the calculated use volume of 35,000 dam^3/y without wildlife conservation allocations. The reasons for this are:

- The calculated uses are estimated in a deterministic fashion, meaning all uses are estimated whether or not they would impact surface flows and whether or not they are licenced. The simulated use figures only include the licenced projects within the effective drainage area. Thus, calculated uses would be expected to be higher, as they include those which do not require licencing and those from the entire drainage area.

- Different data sets are used in each instance. Calculated uses are based on recorded data, licence data and use estimates based on statistical data. Simulated use figures are based on observed runoff data and licenced water use data.

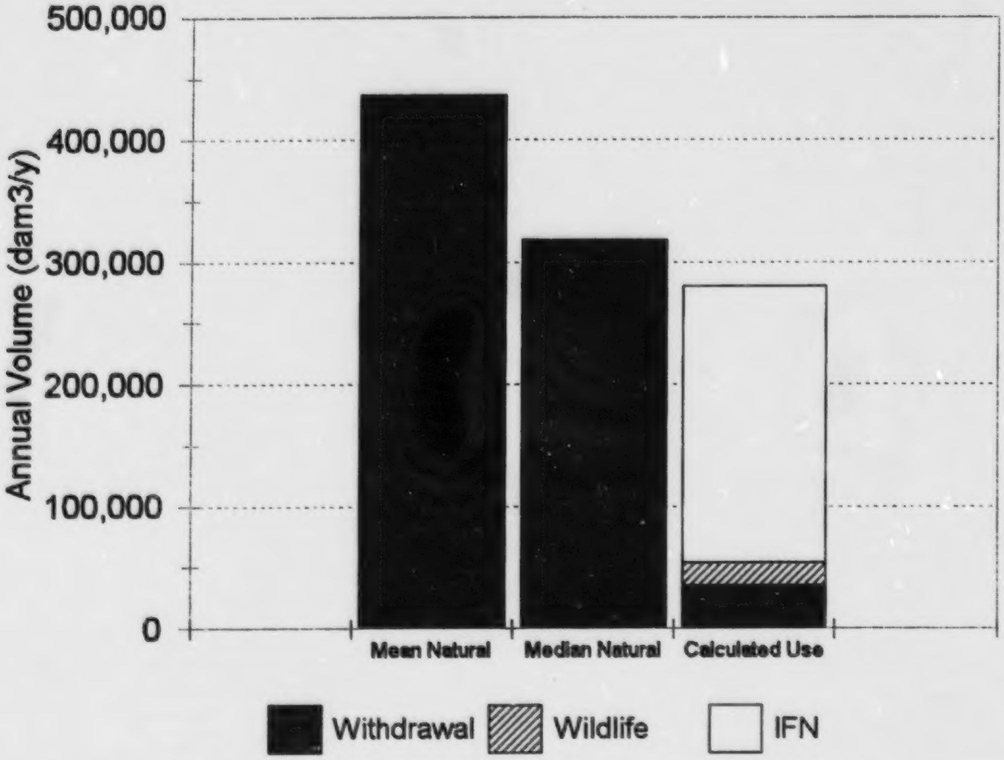
Figure 5.1
Median Annual Flow and Annual Withdrawal Use



Both water use estimates are valuable. The calculated water use figures provide an estimate of how much water is being used in total, independent of its effect on the source. The simulated use figures provide an indication of how the water use in the Basin actually impacts the flows and what water remains available for further uses.

Figure 5.1 shows that for the Basin as a whole on a median year, the water supply of 320,000 dam^3 is significantly greater than the calculated water uses. Figure 5.2 shows the same figures with the addition of the water volume necessary to provide desirable instream flows for the Assiniboine River below the Shellmouth Dam. In addition to the median natural flow volume the mean natural flow volume is also shown. The data suggest that on a median year, there is sufficient water available in the Basin to satisfy all the water uses and yet provide ideal instream flows at the Basin outlet. Such a condition represents an ideal situation with sufficient infrastructure to make it possible. This represents development which is presently technically and financially unattainable. The mean annual flow volume is shown because the instream flows were estimated based on means, and compared to the median flow appear large. Another analysis may estimate instream flow needs based on median flows.

Figure 5.2
Annual Flow and Annual Total Use



The next level of examining supply and use would be to look at the historical annual volumes in the Basin and how they compare to the water use, thus providing recognition of the year to year variation in water supply. Figure 5.3 shows the natural annual volumes of the outlet reach and the proportion of that flow which is lost to uses (shown in black), based on the simulated water uses. The proportion of natural flow which is not used is shown in white. The uses are small compared to the annual volumes. Further, the total calculated annual surface water use from Chapter 3 of 35,000 dam^3/y (without wildlife conservation project allocations) represents approximately half of the lowest annual volume in the period of record of 74,000 dam^3 in 1961. (Appendix II lists the estimated natural annual volumes for the Basin outlet). It can be concluded that there is sufficient water available in the Basin to satisfy all withdrawal uses given sufficient infrastructure, whether or not that level of development is realistic.

Figure 5.3
Annual Flow Volumes vs. Annual Uses

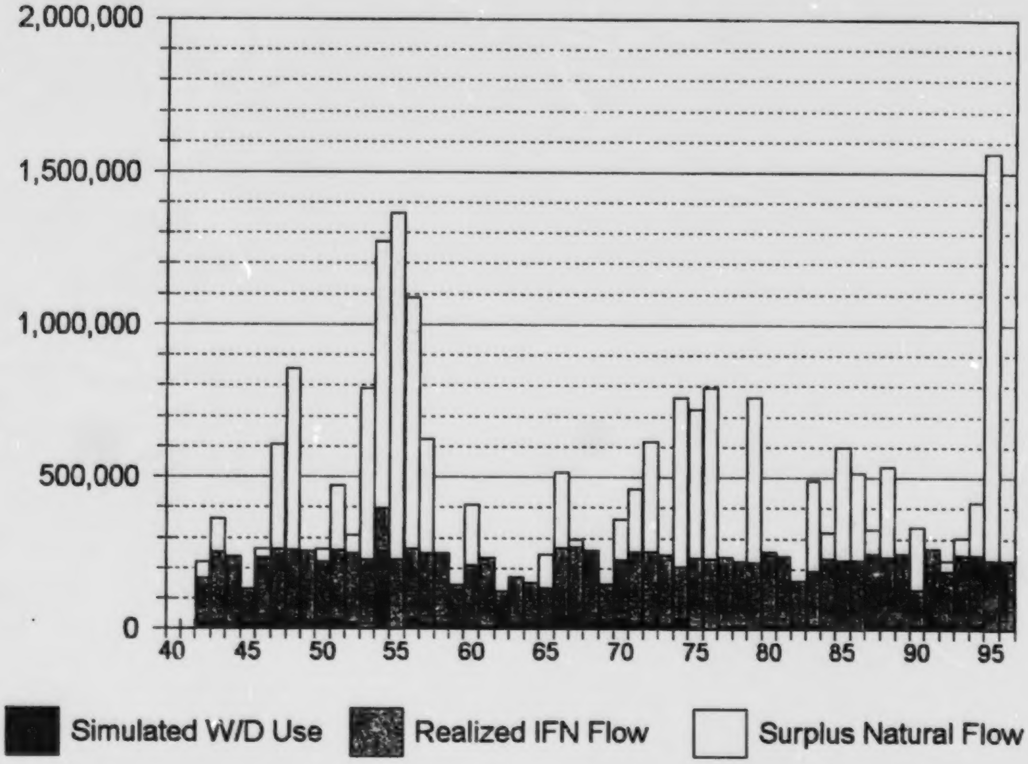


Figure 5.3, also shows the volumes necessary for desired instream flows when included as a use (represented by the grey shading) to either the full amount desired or to the limit of the available water. Excess runoff for both simulated withdrawal uses and instream flow needs is shown in white. The volume of water required to produce desirable instream flows is again shown to be significant, so much so that in roughly one third of the years (19 of the 55 years) the annual natural flow volume available was insufficient to completely satisfy the desirable instream flows. This information is presented for illustration only, as a more detailed discussion of desirable instream flow needs can be found later in this chapter under the heading "Detailed Analysis."

5.1.1.2 Simple Analysis - Other Locations

The model can be used to examine the natural and regulated volumes in any channel. As example stretches, the median annual natural and regulated flow volumes for four other river stretches are shown in Figures 5.4 to 5.7 and discussed herein as examples of the supply and use status within the Basin.

(1) Shell River above Lake of the Prairies

Figure 5.4 shows the median annual volumes for the Shell River just above Lake of the Prairies (and below the Asessippi Ski Hill withdrawal). Although not noticeable on the figure, the median annual regulated flow is approximately 175 dam^3/y less than the natural flow, representing the use of upstream irrigation projects and the Asessippi ski hill. The figure demonstrates that uses in the watershed are small compared to median runoff volumes.

(2) Assiniboine River near Kamsack

Figure 5.5 shows the median annual volumes for the Assiniboine River below the Kamsack weir. Again, although it is not noticeable in the figure, the median annual regulated flow is approximately 750 dam^3/y less than the natural flow, representing the use of upstream irrigation projects and the Town of Kamsack uses. The figure also demonstrates that uses are small compared to median runoff volumes.

(3) Yorkton Creek/Cussed Creek near Ebenezer

Figure 5.6 is designed to show the effect of use and regulation on the Whitesand River near Ebenezer. Included is the net effect of the Willow Brook diversion into the Yorkton South Complex, the regulation of the Yorkton Creek headwaters by that Complex and the City of Yorkton effluent releases along with any minor uses. The estimated effect is possible because of the previously constructed Yorkton South Complex sub-model, which showed that the works and operation of the Complex actually increased the available water downstream in Yorkton Creek. However, when the effect of the Willow Brook diversion is included, the net effect on the Whitesand River is a decrease of roughly 4000 dam^3/y on a median annual volume basis. Nonetheless, the figure illustrates that the majority of the median annual runoff volumes remains.

(4) Whitesand River below Canora

Figure 5.7 shows that the difference between the median runoff volume with all the use and regulation above and that of natural conditions is approximately 1200 dam^3/y. This figure is slightly misleading, because if one takes the median of the annual differences, it is 2800 dam^3/y (the difference is assumed to be due to the statistics on a smaller sample). Regardless, the net effect is that regulation has less of an effect on the Whitesand near Canora than further upstream near Ebenezer. This is because of the lowering of the FSL of Good Spirit Lake with operation. The central point reflected here is that the figure again suggests that uses are small compared to median runoff volumes.

Figure 5.4
Median Annual Natural and Regulated Flow - Shell River above Lake of the Prairies

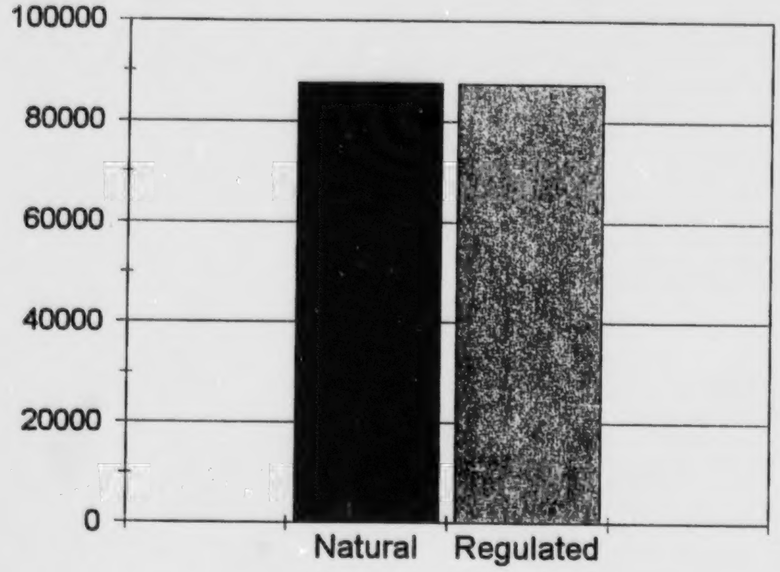


Figure 5.5
Median Annual Natural and Regulated Flow - Assiniboine River near Kamsack

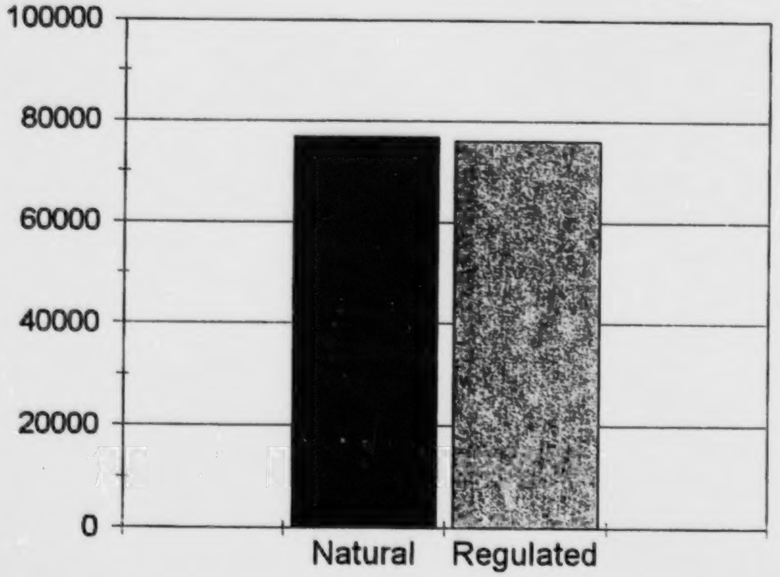


Figure 5.6
Median Annual Natural and Regulated Flow -
Yorkton/Cussed Creek near Ebenezer

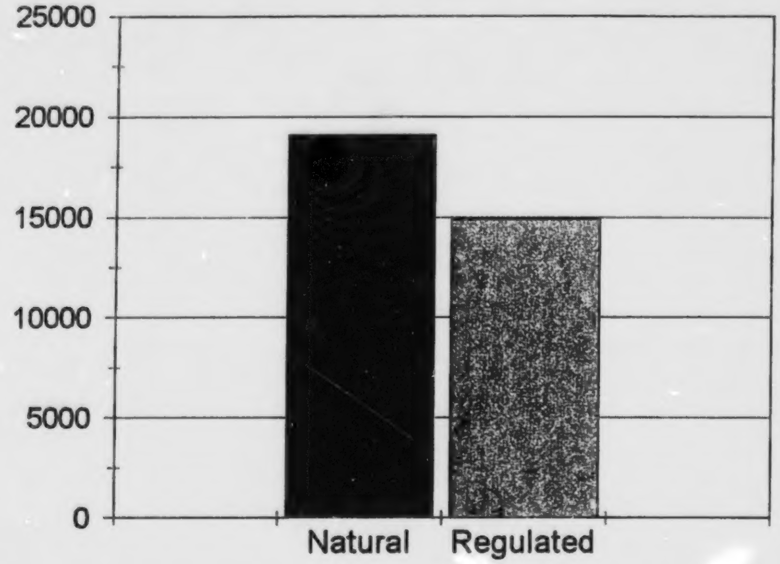
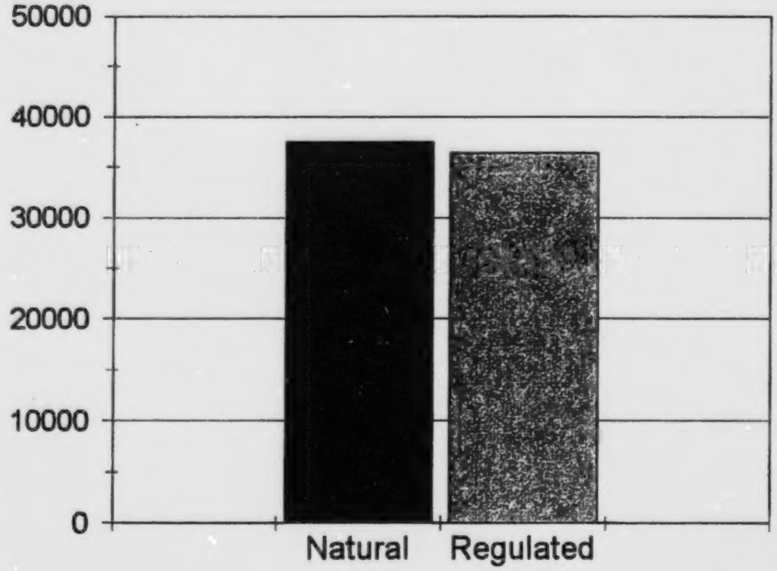


Figure 5.7
Median Annual Natural and Regulated Flow -
Whitesand River near Canora



5.1.1.3 Detailed Analysis

A more detailed look at supply and use for the Basin at its outlet is done on a monthly basis using the model. Figure 5.8 shows the mean monthly flows for the Assiniboine River above the Qu'Appelle River reach for both the natural and regulated cases. The influence of the water use and reservoir effects is obvious. Even though these are mean monthly flows, the peaks are reduced and the overall variability dampened. Figure 5.9 is the same figure only limited to the 1986-1995 period. The effect of the reservoir regulation is more evident, reducing the peak spring volumes but increasing the flow volumes over the summer and winter months as releases from the reservoir. For this particular reach, the flow regulation results from the operation of the Shellmouth Dam. The corresponding simulated Lake of the Prairies elevations are shown in Figure 5.10 along with indications of the desirable recreational operating range. The model is not designed to imitate the forecasted operation of the Shellmouth Dam, thus any conclusions drawn from the simulation may not be supported by a detailed examination of the operation of the dam. Nonetheless, although not obvious from Figure 5.10, the reservoir is most often in the desirable summer operating range except for spring runoff periods.

Figure 5.8
Mean Monthly Flow at the Outlet

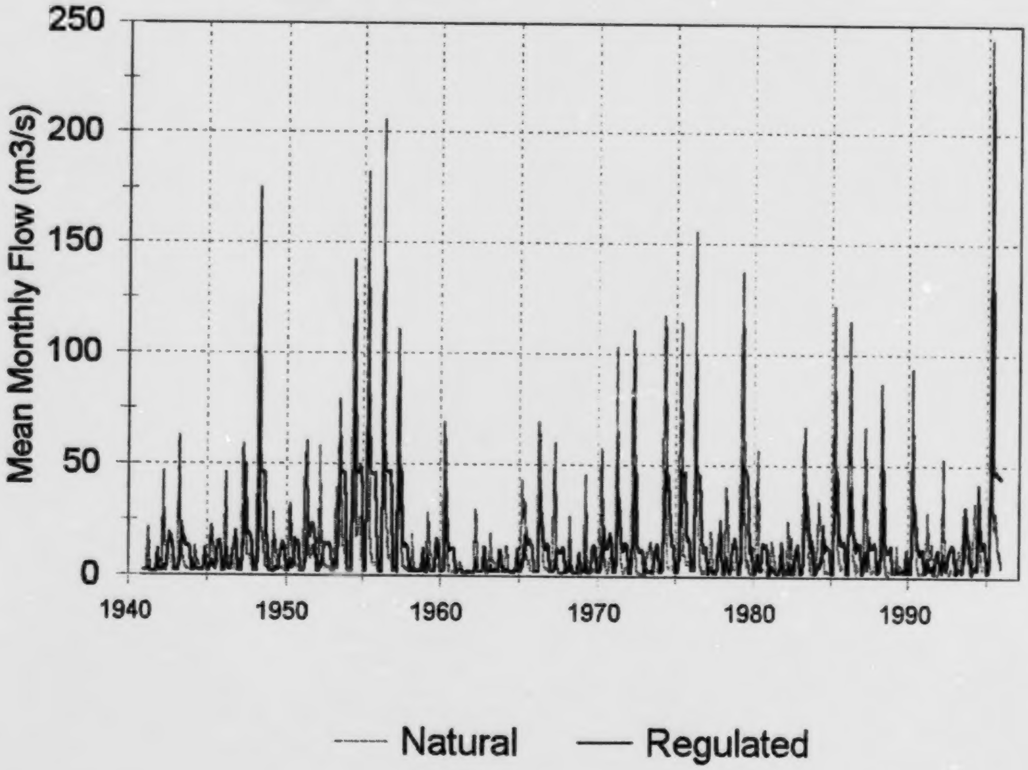


Figure 5.9
Mean Monthly Flow at the Outlet (1986-1995)

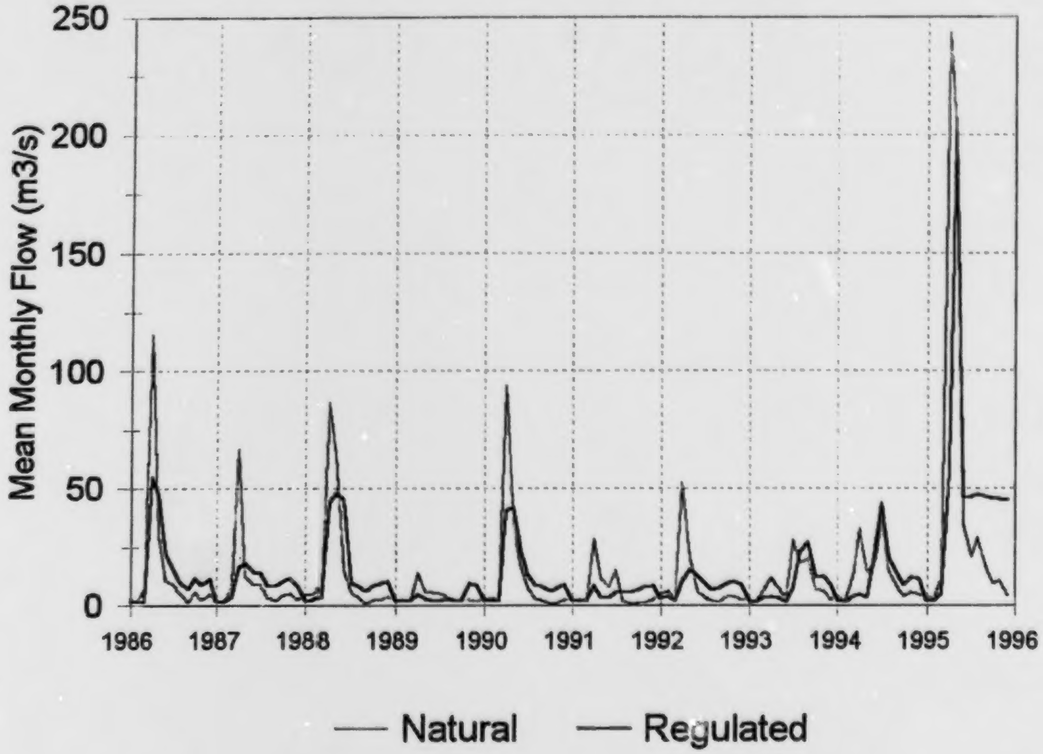
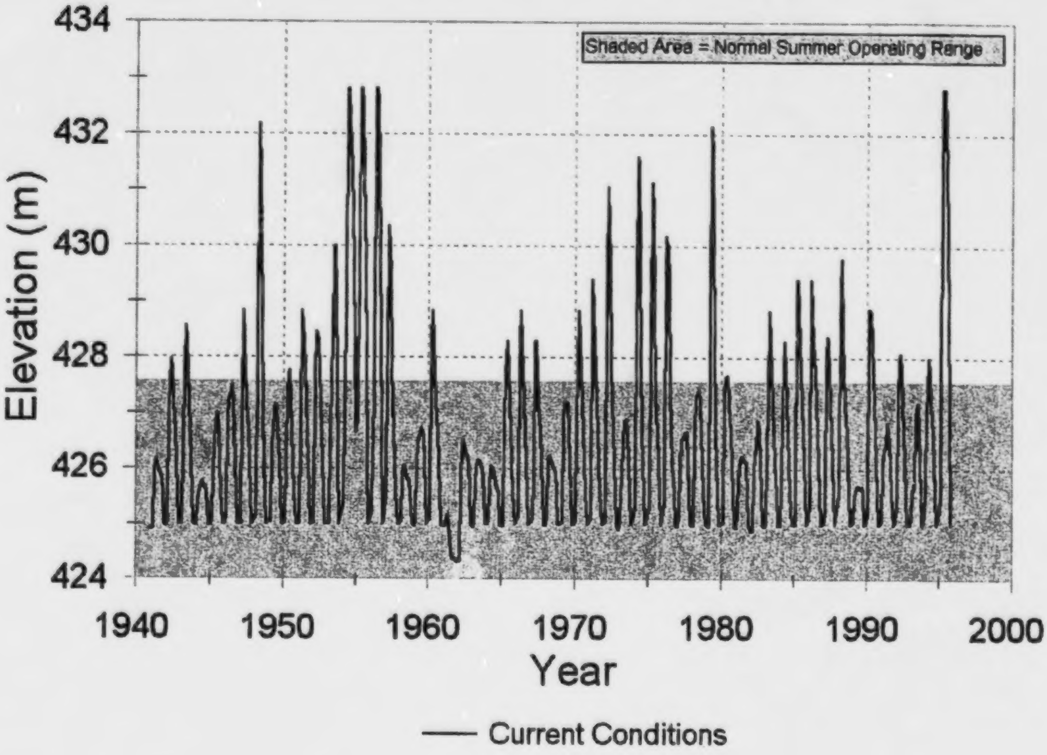


Figure 5.10
Simulated Lake of the Prairies Elevations

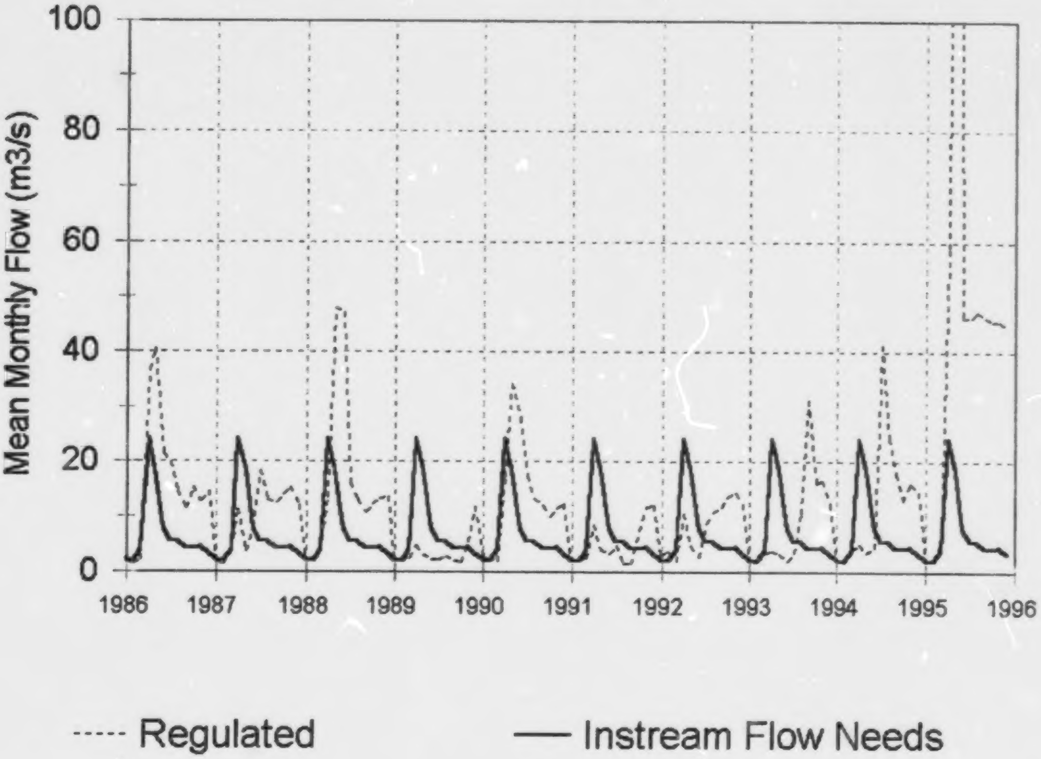


The model included all the major municipal, industrial and irrigation surface water uses in the Basin. Table 5.3 summarizes those major water users and lists the relative amount of time that they receive less than 100 percent of their desired water volume for any given month under current conditions. The data in the table suggest that water uses are met very well, supporting the conclusion that the surface water supply is sufficient for the current level of use development in the Basin. Even the irrigation uses were short only an average of 3 percent of the months in which water was desired, with the highest use shortage only at 6 percent of the months.

With respect to instream flow needs for aquatic life, the ideal situation is to provide completely natural flows, with no regulation or modification. These are the conditions under which fish and other aquatic life have developed and to which they are adapted. Any instream flow recommendation that restricts flows from the natural state is intended only to provide tolerable flows in the face of other competing uses and represents a reasonable flow regime under regulated flow conditions.

For any part of the Basin, it can be determined how adequately the actual (regulated) stream flows meet the desired flow values as represented by the IFN recommendations. As an example, Figure 5.11 shows the regulated flows for the Assiniboine River above the Qu'Appelle River versus the recommended instream flow values. In 46 percent of the months, the existing, regulated flows are less than those recommended by the Tessmann method. When a similar comparison is made for natural flows, 53 percent of months do not meet the IFN values. At first glance, this suggests that neither natural flows or the existing, regulated flows provide adequate instream flows for fish and aquatic life. However, it must be noted that most of the months when flows are less than the IFN recommendation are late summer and winter months. Flows during these months are normally very low. The Tessmann method requests the mean annual flow during these months but it is recognized that it is simply not possible to provide more than what is naturally available and approximately half of the late summer and winter months will fall below the requested values. This is not so much a failure in providing flows as it is a shortcoming of this particular instream flow assessment method. Nonetheless, the analysis suggests that the reservoir operation has augmented downstream river flows during some minimum flow periods and thus has dampened the extreme low flows of prairie hydrology to some extent.

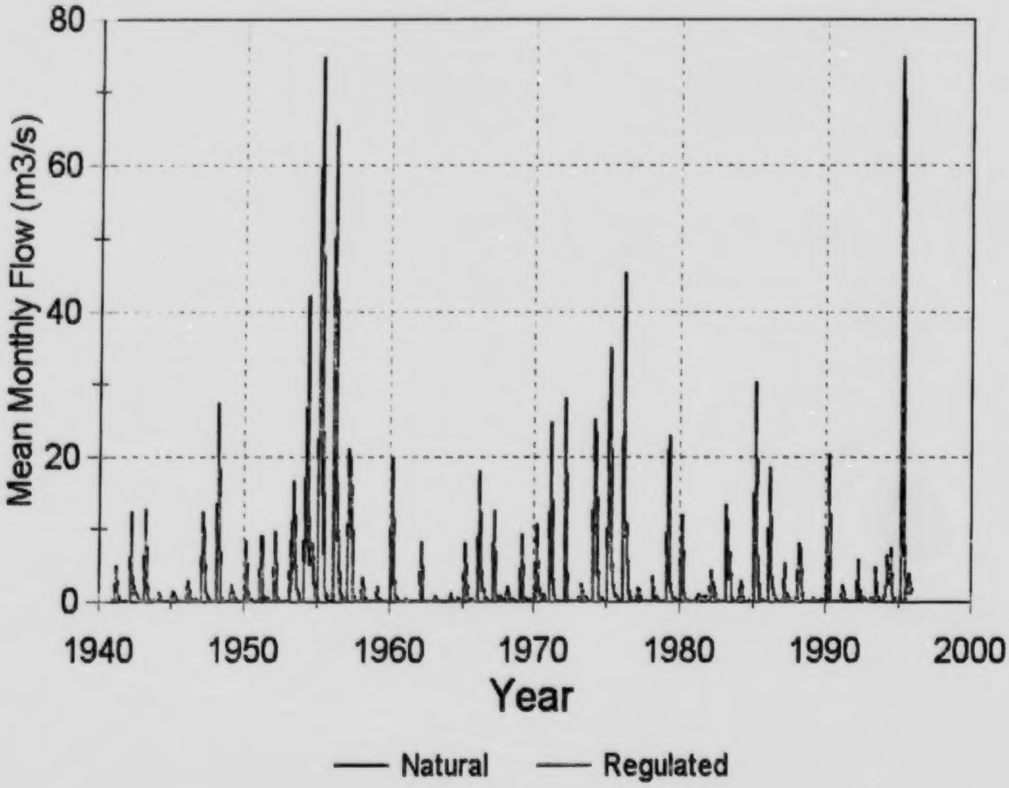
Figure 5.11
Mean Monthly Assiniboine River above Qu'Appelle Flow vs. Instream Flow Needs



The natural variability of stream flows in the Assiniboine River means that during low flow periods, water diverted for offstream uses could potentially compromise the instream ecology. Figure 5.11 illustrates this variability and shows that there is considerable water available for offstream use in some years but in other years instream flow targets cannot be met, much less provide additional water for offstream use without having some impact on the aquatic environment. Thus, in an average year, some form of storage infrastructure would be required to provide both security of supply and the maintenance of instream flows.

A similar examination can be made at the outlet of any of the watersheds in the model. For example, the natural vs. regulated flow for the Whitesand River near Canora are shown in Figure 5.12. The effect of current uses on the natural flows can be examined, as well as the water available for further development.

Figure 5.12
Whitesand River near Canora Mean Monthly Flow



In summary, the current level of water use in the Basin appears to be sustainable. Water shortages for withdrawal uses do not appear to be a concern based on the result of the modelling. Achieving desirable instream flows for fish downstream of the Shellmouth Dam appears to have been aided by the construction and operation of the dam, however achieving these flows proves to be very difficult because of the inherent extremes of prairie hydrology.

Table 5.3 - Dependability of Supply for Major Water Uses (Current Conditions)

Category	Specific Use	Months Short of Total Desired	
		no. out of 660	% of Total
Municipal / Industrial	Rama	0	0
	Canora	0	0
	Kamsack	0	0
	Asessippi Ski Hill	0	0
	Canamera Foods	0	0
	Average	0	0
	Median	0	0
Irrigation	WRMM Irrigation Project I.D. Number*		
	61	6	1
	62	2	0
	261	3	0
	361	12	2
	362	7	1
	363	0	0
	461	26	4
	462	19	3
	463	16	2
	464	38	6
	465	33	5
	561	5	1
	562	5	1
	563	5	1
	564	0	0
	565	0	0
	660	0	0
	661	0	0
	662	0	0
	760	0	0
	761	0	0
	762	0	0
	763	0	0
	764	0	0
	765	0	0
	766	10	2
	767	24	4
	768	6	1
	Average	7.75	2.8
	Median	4	1.5

* - Irrigation project numbers are defined in Appendix VII

Table 5.4 - Assiniboine River at Confluence with Qu'Appelle - IFN Performance

Scenario	Months Short of Total Desired	
	no. out of 660	% of Total Months
Natural Flow	351	53%
Regulated Flow	303	46%

5.1.2 Future Use Conditions

An examination of how well the major water users were satisfied under future municipal surface water demands (as outlined in Chapter 3.3.1) and increased industrial demands was conducted. In the model run, Rama, Kamsack, Canamera Foods and Asessippi Ski Hill uses were all increased by 20 percent. Canora demand was set to zero reflecting the community's move to groundwater. This reflects a 2020 level of development for municipal uses and an arbitrary increase in industrial water uses.

The analysis found that the increased demands had no effect on water shortages at all, for any user (including the irrigation projects) as the results were exactly the same as illustrated in Table 5.1. Inspection of Assiniboine River Flows near Kamsack and below Shellmouth Dam and Lake of the Prairies Elevations revealed no discernable differences from current conditions, therefore the plots are not provided here.

Although the overall water supply in the Basin appears to be sufficient, industry could be challenged by the availability of good quality water. Safe and dependable water supplies are essential to livestock. In areas where only poor quality surface water or groundwater is available or the supply is not dependable, remedies may include storage and transport of higher quality water and/or the application of new treatment technologies.

5.1.3 Demonstration Runs

5.1.3.1 Effect of Asessippi Withdrawal

The model was also run without the Asessippi Ski Hill withdrawal in place in order to demonstrate the effect the withdrawal would have on Lake of the Prairies levels and downstream flows had it been in place over the historical period. The withdrawal was equal to the annual allocation of 70 dam^3 and was removed over the winter months. Inspection of Lake of the Prairie elevations and river flows below the project showed no discernable differences from current conditions, therefore the plots are again not provided here.

5.1.3.2 Operating Reservoirs to Meet Desired Instream Flows

When a reservoir with appreciable storage is located above any reach and there is sufficient control on the releases from that reservoir, an opportunity to enhance downstream flows is available. There are two reservoirs in this Basin which are capable of storing and releasing sufficient water to aid instream flows, Lake of the Prairies and Theodore Reservoir. Two model runs were conducted to examine enhanced instream flows below the reservoirs and the associated cost to water levels in the reservoirs. The combination of reservoir/reaches chosen were Lake of the Prairies and the Assiniboine River above the Qu'Appelle River and the Theodore Reservoir and Whitesand River near Canora.

In both instances, maintaining desirable channel flows (as defined by the Instream Flow Needs analysis of Chapter 3.4.2) was considered to be the second highest priority for each reservoir. The first priority remained the withdrawal needs (municipal, industrial and irrigation uses) of the river reaches, with maintaining reservoir levels least important. The reservoirs were allowed to be drawn down completely to the structure inlet elevations if needed. Figures 5.13 and 5.14 show the Lake of the Prairies levels and Assiniboine River flows which would result for the entire simulation period, while Figures 5.15 and 5.16 show the same but only for the period from 1966-1975. Similarly, Figures 5.17 through 5.20 show the same data for Theodore Reservoir and Whitesand River near Canora. Table 5.5 lists the proportion of months the flow was less than the IFN identified for each scenario.

Table 5.5 - Assiniboine River at Confluence with Qu'Appelle - IFN Performance

Scenario		Months Short of Total Desired	
		no. out of 660	% of Total
Lake of the Prairies / Assiniboine River at Qu'Appelle	Natural Flow	351	53%
	Regulated Flow	303	46%
	Reservoir Operated for IFN	200	30%
Theodore Reservoir / Whitesand River below Canora	Natural Flow	480	73%
	Regulated Flow	483	73%
	Reservoir Operated for IFN	360	55%

Figure 5.13
Lake of the Prairies Levels - IFN Priority

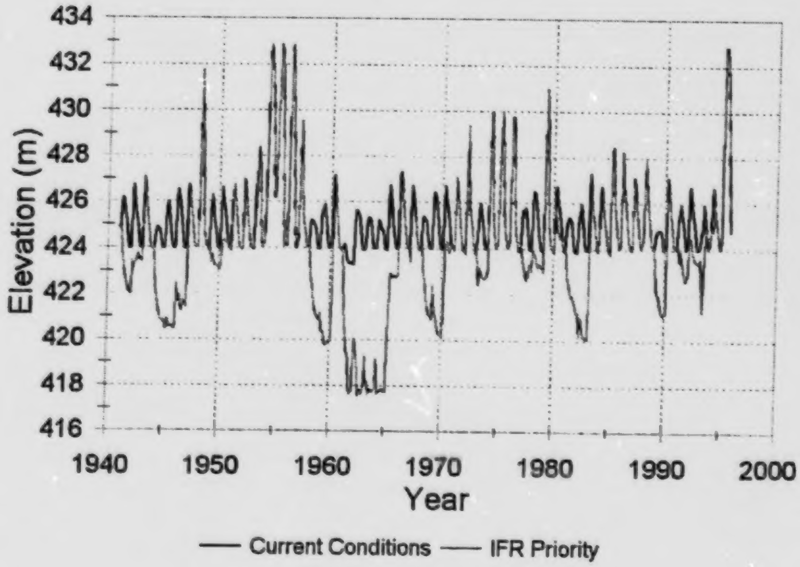


Figure 5.14
Assiniboine River above Qu'Appelle River - IFN Priority

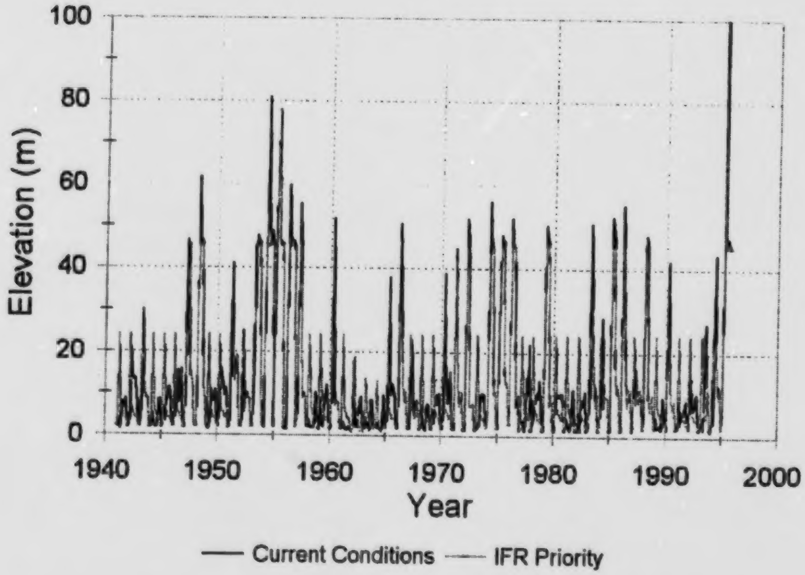


Figure 5.15
Lake of the Prairies Levels - IFN Priority (1966-1975)

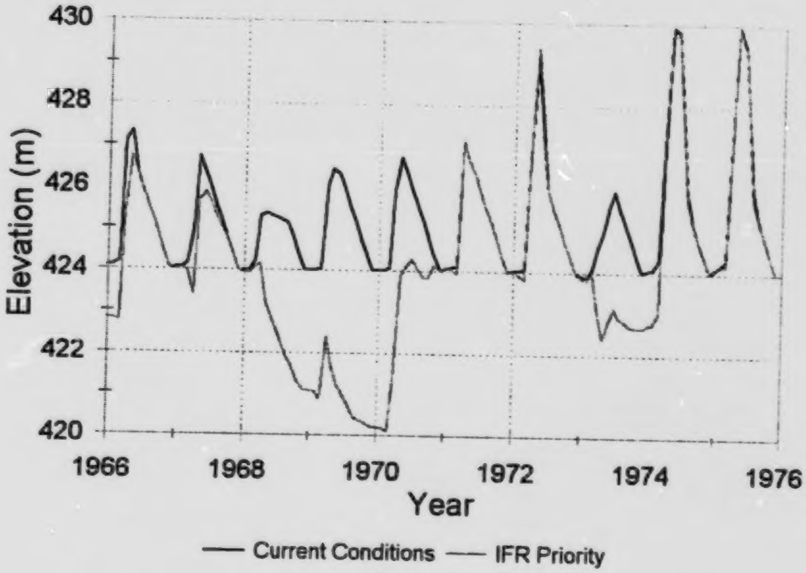


Figure 5.16
Assiniboine River above Qu'Appelle River - IFN Priority (1966-1975)

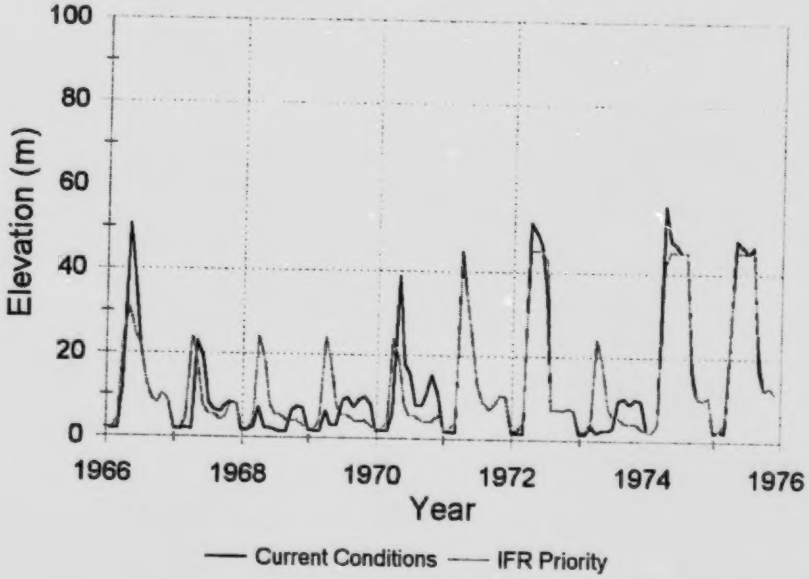


Figure 5.17
Theodore Reservoir Levels - IFN Priority

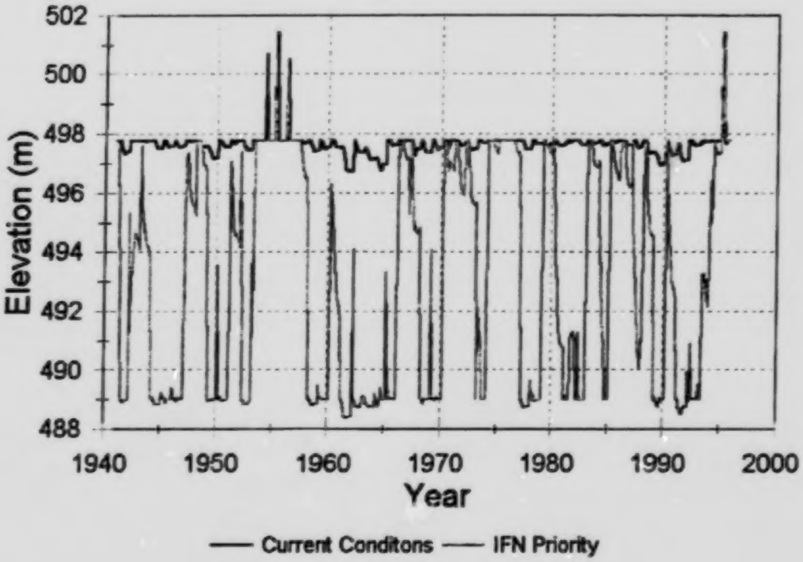


Figure 5.18
Whitesand River near Canora - IFN Priority

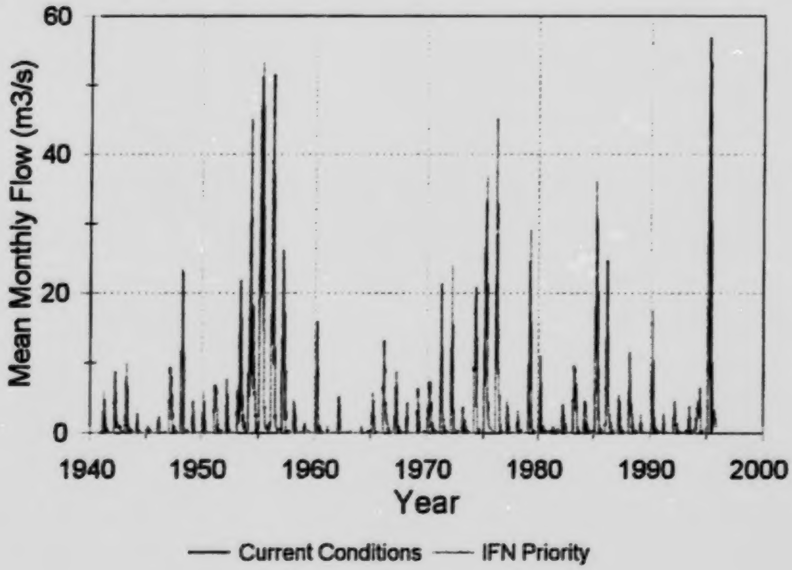


Figure 5.19
Theodore Reservoir Levels - IFN Priority (1966-1975)

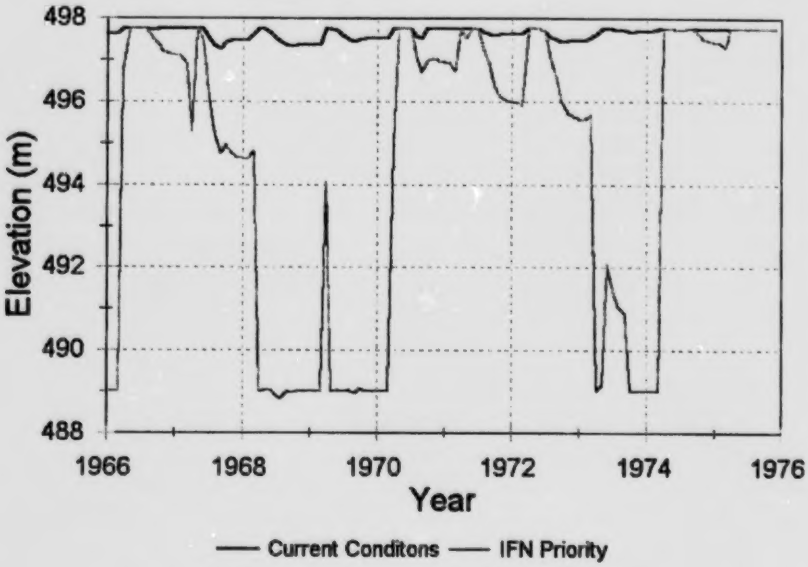
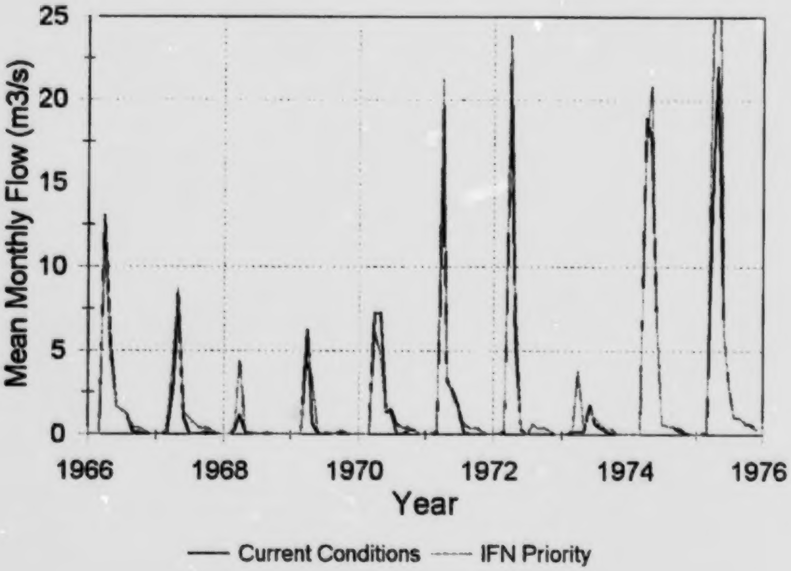


Figure 5.20
Whitesand River near Canora - IFN Priority (1966-1975)



The result of the analysis indicates that the instream flow needs can be somewhat addressed by reservoir operation, but at great cost to the elevations in the reservoirs. This type of management approaches the best possible instream flow conditions below the reservoirs, because any water which can be provided from the reservoir is sent downstream if needed.

The existence of the reservoirs provides some flexibility for water managers to provide the recommended flow volumes at downstream locations. However, the problems associated with strict adherence to recommended instream flow values are obvious in the fluctuations of reservoir elevations. These fluctuations would be harmful to the fish populations resident in the reservoirs, the recreation industry and any other users of water in the reservoir. This analysis illustrates that there are always compromises when there are competing uses for water in a reservoir.

5.2 Groundwater Supply vs. Use

Unlike surface water, strictly comparing the supply versus the use of groundwater is not simple. The state of groundwater supply verses use in the Basin cannot be described by simply stating when the supply is adequate or inadequate or indicating that volumes are available from a certain aquifer. The volumes of groundwater available for development are unknown for most of the Upper Assiniboine River Basin.

Groundwater management involves reconciling what is known about the groundwater supply to the desired uses. Basin yields are rarely known. Aquifer yields are seldom known, but sometimes can be inferred from mapping and pumping/monitoring data. Well yields are essentially known although the data may not have been gathered and analysed and the aquifer identified. Depending on the amount of knowledge and the implications of supply shortages, there can be three approaches to groundwater management:

(1) An unregulated approach, where no attempt is made to determine the yield of the aquifer or to monitor the effect of pumping on the aquifer. This represents a reactive management approach as problems are dealt with as they occur.

To some extent, the known ability of an aquifer to supply water may be defined by the use from the aquifer, i.e., if a certain level of use has been supported by a particular aquifer with no adverse impacts, the corollary is that the aquifer must then be capable to supply that amount. Provided the level of use does not change and the aquifer continues to be able to supply the water, i.e., no change in recharge, then further management of the resource may not be necessary. Although the overall groundwater supply is not known, this approach renders a detailed knowledge of the hydrogeology unnecessary from a withdrawal perspective. This approach is taken to its extreme with completely unregulated uses, that is the well is pumped as long as the aquifer will supply the water and the user with the deepest well and/or the largest pump can withdraw the most water.

(2) A detailed aquifer management plan approach, where a comprehensive knowledge of the geology and hydrogeology (including the interactions with surface water) is determined and provides a detailed understanding of the extent and behaviour of all aquifers, their sustainable yields, recharge sources and water quality. This approach is extremely data and analysis intensive and requires significant resources, but facilitates the proactive management of groundwater.

(3) An approach anywhere between the above two extremes, where practical groundwater management may be at either extreme, but more often the approach lies somewhere in the middle. This approval requires some exploration and technical analysis to predict that a certain withdrawal is sustainable, followed by monitoring to verify that it is sustainable. Although a well may be producing acceptably (meaning the aquifer is successfully providing the desired supply) the addition of another use may be all that is required to enter a state of overproduction and threaten the aquifer. Thus, an approach between the two extremes also represents reactive management, albeit to a lesser degree. The total yield of the aquifer does not have to be determined, and because some analysis and monitoring is in place, overproduction will be discovered more quickly than with option (1) above.

In Saskatchewan and Manitoba, domestic use of groundwater is not regulated. Domestic water i generally thought of as a reasonable amount for the use of a house, yard, and limited number of livestock obtained from a source other than a municipal or community distribution system. In Saskatchewan, there is no set production level cutoff below which a well is considered domestic, while in Manitoba use is limited to 25 m^3/d. Generally, domestic uses are relatively small and in most areas wells are sparse, meaning that uses will not usually adversely affect surface and groundwater resources. Thus, regulation is often not advantageous. In fact, the aquifers are often not mapped. The advantages of more vigilant groundwater management increase with well density and total use.

Any non-domestic groundwater use requires regulatory approval. As conditions of that approval, Saskatchewan and Manitoba can require whatever level of subsurface investigation, pump testing, or monitoring may be necessary to ensure the integrity of the groundwater resource. The applied principle is that developers must demonstrate that their projects are sustainable and that they are prepared to mitigate the effects of their use on other users if necessary. All approvals for groundwater use (Appendix III) have appropriate conditions attached to ensure protection of the aquifer and that any impacts to other users are appropriately mitigated. These conditions will include water level, water quality and production monitoring to improve the knowledge and management of the resource. As resources permit, the regulatory agencies in each respective province will review the licencing data to ensure proper groundwater management.

An example of this approach is the Town of Canora groundwater supply. Although preliminary work has been done to define some aquifer characteristics, the extent of the aquifer and its maximum sustainable yield is not definitively known. However, based on a review of basic data, aquifer exploration, and pump testing along with appropriate technical analysis, the aquifer is thought to be capable of providing Canora with a long term sustainable water supply (Beckie Hydrogeologists 1999). Even though the use is believed to be sustainable, long term monitoring of the aquifer response to pumping will be used to verify if the aquifer is being pumped at sustainable levels. Should it become apparent that the aquifer is being excessively pumped, the relatively slow response times will allow some time for the user to adjust to the situation. Therefore, should Canora's withdrawals prove to be unsustainable, there should be sufficient warning to set up an alternate water supply for the town. Should another user wish to withdraw water from the aquifer, the proponent would be required to demonstrate that the additional use is also capable of being sustained. A condition of another approval may include mitigation of any effects on Canora's wells. Taken to the extreme, should sufficient development pressure lead to serious concern over the safety of the aquifer or the possibility of water shortages, a detailed aquifer management plan may be warranted. At some point, it may even become clear that additional uses would not be sustainable and further development would be prohibited.

Detailed aquifer management plans require sufficient data to define the geology, hydrogeology, recharge mechanisms and safe yield of the aquifer or aquifer systems. Obtaining detailed knowledge requires significant resources which is provided by stakeholders who fund the plan and provide representatives to manage and administer the plan. Stakeholders may include local and provincial government agencies and private industry. The work involves obtaining the necessary technical knowledge to ensure the aquifer system(s) are being managed in a safe and sustainable way. This may include comprehensive hydrogeology studies (exploration, analysis of geological, hydrogeological and water quality data), water demand studies, aquifer sensitivity mapping and land use planning. The aquifer management plan itself may be comprised of an aquifer allocation plan and an aquifer protection plan.

Currently, the only area in the Upper Assiniboine River Basin in which a formal aquifer management plan is being developed is the Yorkton area. Exploration and analysis to define the complex geology and hydrogeology of the Yorkton aquifer systems is ongoing, accomplished in steps as resources permit. The overall water supply and demand relationship for the City of Yorkton is complex and involves withdrawals from five well fields. To date, key areas of the major aquifers used by the City of Yorkton have been delineated and an estimate made of the sustainable withdrawal rate. Although only an estimate and subject to further refinement with continued work, the sustainable yield of the Yorkton aquifer system is thought to be in the range of 2000-2700 dam^3/year (Maathuis 1991). It should be noted that subsequent work suggests that the sustainable yields may in fact be higher. Yorkton water use has averaged 2200 dam^3/year, thus the withdrawals from the current aquifer systems may well be at their limits. In order to accommodate a new major water user, it would be necessary to secure a new source either within or beyond the current aquifer systems. Long term plans also include an aquifer protection plan which may regulate land use where the aquifer systems are extremely vulnerable to contamination. The need for aquifer protection is highlighted by the connectivity of the Logan East well field with Yorkton Creek, where colour problems in the well water were attributed to induced creek water (Maathuis and Campbell 1996). It is thought that up to 50 percent of the well field withdrawal may be annual recharge from the Creek. The well field provides about 30 percent of Yorkton's annual water supply (Maathuis 1991).

At the present time, no other formal aquifer management plans are envisioned for the area coincident with the Upper Assiniboine River Basin. However, concerns over the sustainability of any aquifer or aquifer system may be only "one use away" or "one drought away" and other aquifer management plans may warrant consideration. Currently, development stresses on aquifers are being handled within the regulatory process.

5.2.1 Summary

The state of the groundwater supply as compared to the level of groundwater use in the Basin is not a simple concept. Ideally with unlimited resources, the complete extent and sustainable yields of all aquifers would be known, and thus the amount of groundwater available would be quantified. This level of knowledge would facilitate a completely proactive groundwater management approach. Resource management agencies should be striving to achieve that state of groundwater knowledge to the extent that is reasonable.

Groundwater mapping is fundamental to management of the resource. Currently, there is more data available for mapping of the Basin than has been used in the supplementary reports. Therefore, all known aquifers are not shown. The data available for mapping include numerous drillers logs, electric logs and various maps and reports. The nature of the data sources and the high level of skilled interpretation required means mapping does not lend itself well to automation. The best information are geophysical logs (most often electric logs) which are not conducive to automated mapping techniques. Although the drillers database is digital, there are no data standards and the data are not of sufficient quality to produce useful maps for resource evaluation or site specific investigations. Comprehensive groundwater mapping would include collection of all data, data quality verification, geologic/hydrogeologic interpretation and mapping, targeting exploration in key areas of missing data, and the analysis of hydraulic and water quality data. The net result would be a definition of the hydrogeological system, production capabilities and water quality characteristics of the aquifers and aquifer systems.

Where development pressures warrant, detailed resource evaluation and an aquifer management plan is needed. Currently in the Basin, the only area where a formal aquifer management plan exists is the Yorkton area. However, any aquifer in which significant uses are proposed or shows signs of deleterious water levels or overpumping, may warrant detailed aquifer management in the future.

Without the resources to implement completely proactive groundwater management, reality dictates that a certain level of reactive management is necessary. In fact, this is the usual approach taken with groundwater management for almost all of the Basin. This means that rather than be completely concerned with the total amount of groundwater availability, the regulatory agency concerns itself more with ensuring the aquifer is capable of sustaining the uses that withdraw water from it. Although the approach requires less resources to manage groundwater, there is a greater chance that individual or more general aquifer supply problems may occur. In Saskatchewan and Manitoba, the general procedure is for the proponents to provide the pumping and/or water level data while the provinces provide the analysis. However, there is room for improvement in both jurisdictions as the data is not always provided nor is it always subjected to an appropriate level of analysis.

5.3 Potential Influences on the Supply/Use Relationship

5.3.1 Drainage

Examining potential changes in the water supply and use relationship due to drainage involves examining the effect of drainage on water availability. It requires either looking at the historical effect of drainage on water availability or a predictive approach involving estimates of future changes in water availability based on some hypothetical level of future drainage. As noted in Chapter 2.1, attempts to estimate the historical effect of drainage on water supply would provide technically indefensible results.

A predictive approach may provide estimates of future water volumes that could be made available downstream by drainage that are potentially technically defensible. Any approach would likely require a detailed examination of the wetland hydrology including a detailed analysis of drainage areas, current wetland storage volumes and spill characteristics. The level of data and analysis required would be very complex and is beyond the resources of this Study. More importantly, the information gained in such an exercise probably does not justify the level of effort required to obtain it. Current water uses in the Basin appear to have dependable supplies, particularly in the lower part of the Basin. Where supply may be less dependable, it probably has more to do with insufficient storage or other infrastructure rather than water supply. Therefore, examining how much additional water can be made available in the lower part of the Basin does not justify the large effort which would be required. Any further drained water from the headlands is not needed in the lowest portions of the Basin (Lake of the Prairies or in the Assiniboine River below Lake of the Prairies) as uses currently have adequate supply.

The role of wetlands in hydrogeology can be examined at the local scale and regional scales. A review of these roles has been conducted by van der Kamp and Hayashi (1998). Portions of the following discussion have also been extracted from the supplementary hydrogeology review by Maathuis *et al.* (1999).

At the local scale, wetlands are typically part of very localized groundwater flow systems. Water levels in wetlands are connected to local water tables, which may be higher or lower than the water levels in the wetlands beneath the surrounding topographical highs. Where the conventional concept in hydrogeology that recharge occurs evenly in the higher parts of a landscape and discharge occurs in the lower parts, the water table mirrors the topography. However with the climatic conditions of the Prairies, runoff that accumulates in depressions can also become depression-focussed recharge as introduced by Lissey (1971). The result is a water table that is a reverse image of the topography, i.e., it is high in the depression and low beneath the topographical highs. Both concepts may apply to varying degrees for any particular landscape.

Groundwater flow, therefore, may be into or out of any particular wetland, depending on the position of the wetland in the landscape as well as seasonal and long term climatic conditions. Evapotranspiration around wetlands is commonly replenished by shallow groundwater and only a small amount of wetland water enters larger, regional groundwater flow systems. Drainage would thus result in a lowering of the local shallow water table.

There are two possibilities with respect to the role of wetlands in regional hydrogeology:

- Wetlands over a regional aquifer but separated by a thick aquitard of low vertical hydraulic conductivity - The effect of the surface hydrology on these aquifers is negligible because of the extremely low flow rates through these aquitards (*e.g.* van der Kamp and Maathuis 1991).

- Wetlands over a regional aquifer, separated by an aquitard with fracture permeability - Wetlands are an important source of recharge to aquifers when they are separated by an aquitard with fracture permeability (it is also logical that this would also apply to thinner aquitards of higher vertical permeability). Drainage of these wetlands would affect the groundwater recharge and thus the aquifer yields.

Determining the role of wetlands in the Study area would require a sufficient degree of groundwater mapping and sufficient hydraulic conductivity data for the aquitards of the Study area. Estimating the effect of drainage on the recharge of regional aquifers would require significant effort and resources.

5.3.2 Climate Change

There is an emerging consensus that the temperature of the earth is rising, although it is not necessarily representative of how the atmosphere is responding to long-term, human-induced changes (National Research Council 2000). Expectations of significant global greenhouse warming rest on a combination of scientific fact and projections based on a diverse battery of computerized General Circulation Models (GCMs). Regardless of the causes, if global warming is occurring it could potentially affect the availability of water or water use.

Scientists use GCM models to make their best guesses about future changes in climate. A GCM is a computer model representing the atmosphere, oceans, land and icecaps. By solving mathematical equations based upon the laws of physics, a GCM simulates the behaviour of the climate system. The problem is that computer models cannot yet reliably factor in everything that affects climate and furthermore they are limited by their inability to provide projections at appropriate spatial scales. Small-scale phenomena are poorly captured affecting simulated patterns of temperature and rainfall, and hence the ability to realistically simulate observed regional climate for the Prairies, let alone for the Upper Assiniboine River Basin.

The wide range of predicted changes in runoff by the GCMs for the Prairies basically illustrates that it is not known how Prairie hydrology will change due to global warming. For example, Natural Resources Canada (1998) notes that current models *suggest* that climate change *could* result in increased air temperatures and decreased soil moisture, but that there is even less confidence about whether precipitation will increase or decrease on the Prairies. Large uncertainties exist as to the changes in precipitation, evapotranspiration, soil moisture, runoff, etc. that may occur, therefore it is not known if more or less water would be available.

The net result is that current predictions of climate change based on GCMs is of little practical use. An alternative to predictions of climate change is to advance potential climate change scenarios to see how the system reacts. A climatic change scenario has been defined as a description of the spatial patterns and seasonal behaviour of temperature, precipitation, and other important meteorological variables in an altered climatic state. Climatic change scenarios of various types have been used, including historical analogues, synthetic, GCM-based, hybrid climatic change scenarios. As of 1999, suitable methodologies to create climate scenarios for the Prairies were just being developed (E. Wheaton, Saskatchewan Research Council, pers. comm.) and were not available for practical application.

From a water management perspective, planning for climate change is somewhat encompassed in "ordinary" water resource planning. Water management in the Prairies involves accommodating variability in flows, whether they are strictly natural, regulated, or affected by other factors such as climate change. Possible problems imposed by climate change are also somewhat addressed as managers better account for the natural variation of Prairie water supply and problems posed by changes in water use. Any potential changes in water supply by factors such as climate change must be judged against the significant uncertainties already incorporated in the design of water resource systems, and that adaption to climate change is also good water management practice.

Potential climate change could not only have an impact on water supply, but also on water use. Whether or not water use would increase or decrease depends on the nature of the effect of potential climate change on the region. Water demand could be expected to increase if the areas became drier, but decrease if it became wetter. Again, since it is not known how Prairie hydrology will change due to global warming, any proposed water use changes would only be speculative.

In light of the current water supply and use relationship in the Basin and the fact that any climate change scenarios would be simply hypothetical and essentially variations on the natural or recorded water supply, the issue was not pursued. It would be possible to run the WRMM model with more extreme droughts and floods, but the value of those runs are questionable when water resources management in the Prairies is regularly trying to accommodate the natural variations in supply. Should suitable climate change scenarios be developed for the Prairies, it may be beneficial to apply the methods to observe if any change in the supply and use relationship will result.

6 Summary

The water supply and the water use in the Basin was characterized, and where applicable they were compared to give an indication of the state of the supply vs. the use. Future water use was also briefly examined with respect to growth and potential future supply and use relationships. Water uses were considered in two categories - withdrawal uses and instream uses. Water supply was examined in terms of surface water and groundwater.

Withdrawal water use estimates originate from recorded data, licenced allocation data, and estimates based on analysis of census data. Total water use in the Basin is estimated at approximately 64,000 dam^3/y if wildlife conservation project allocations are included. Evaporation is the largest user in the Basin at approximately 24,000 dam^3/y. Although water is likely not consumed, water reserved for wildlife conservation allocations is approximately 19,000 dam^3/y and represents the second largest water user. Agriculture uses 12,000 dam^3/y, municipal use is 5500 dam^3/y, and industrial uses are 3600 dam^3/y and they represent approximately 20 percent, 10 percent and 5 percent of the total use respectively.

Instream flow needs for aquatic ecosystems are also quantitatively recognized. Ideally, an unregulated river and completely natural flows are desirable for aquatic ecosystems, however where storage and other uses alter the natural flows, the instream flow needs can be recognized by some type of instream flow recommendation. The Tessmann methodology was used to estimate minimum required mean monthly flows for protection of fish habitat at the outlet of the 23 watersheds.

Total Basin water use is estimated to increase by 5 percent by 2010 and 7 percent by 2020, assuming there are no new major water users in the Basin. The growth in water use will be reflected in the municipal and agriculture categories. Reservoir evaporation, wildlife conservation and industrial uses are not forecast to increase significantly in the future barring the addition of new projects. Wildlife conservation uses are not expected to increase as the main proponent, Ducks Unlimited, has moved away from constructing large wetlands projects. Municipal use is expected to grow by 13 percent and 27 percent by 2010 and 2020 respectively. Agricultural water use is forecast to increase by 18 percent and 26 percent respectively, with the majority of that increase in the livestock sector. In fact, livestock use is forecast to increase by 60 percent by 2010 and by 90 percent by 2020. Water used for crop spraying is small, even if the volume doubles as predicted. Rural domestic use is forecast to decrease slightly.

The type of water supply for each water use, i.e. surface water or groundwater, is known in most instances. Only with some agricultural uses (rural domestic, livestock, crop spraying) does the proportion of water from each source type remain undifferentiated. A reasonable estimate is that 85 percent of uses are supplied by surface water when wildlife conservation projects are included (80 percent when they are not). Surface water provides the majority of water for irrigation, and of course all the water for wildlife conservation projects and reservoir evaporation. It is also thought to be an important source for crop spraying and livestock, as well as rural domestic uses in some areas of the Basin. Data are not available to substantiate the source of water for these uses. Although groundwater only supplies 20 percent of the total uses, it is an important component of both municipal and industrial use, and is expected to be an important source of rural domestic water in much of the Basin. More than 80 percent of municipal water is supplied by groundwater. More than 90 percent of the industrial water use is supplied by groundwater, although some of that use is temporary.

The surface water supply was characterized in time and space by estimating the mean monthly pseudo-natural flows over the historical period of 1941-1995 inclusive and for 23 watersheds within the Upper Assiniboine River Basin. The flows are indicated as being "pseudo-natural" rather than "natural" as it was not possible to eliminate the effects of drainage on the historical record. Although it may have been possible to isolate the effect of drainage on the historical record, the assumptions that would be made would render them technically indefensible. A predictive approach based on some assumed level of future drainage development may have provided future drainage volume estimates that are technically defensible, however the level of data and analysis required would be very large and were beyond the resources of this Study. The effect of potential climate change on water supply and use was not examined, because if the climate is changing it is not known if the Basin will become wetter or drier. Suitable potential climate scenarios for the Prairies have yet to be developed.

The analysis reveals that the current surface water uses appear to be primarily met under current conditions if the previous 50 years or so are representative of the next 50 years. Total estimated surface water use in the Basin is approximately 55,000 dam^3/y when wildlife conservation projects are included, representing approximately 13 percent and 17 percent of the mean annual and median annual natural runoff volumes for the Basin respectively, and approximately three quarters of the lowest annual volume in 1961 of roughly 74,000 dam^3. The model looked at the water supply of the major uses on a monthly basis and found that the surface water uses would have been met to a high degree if they had been in place over the period of record. The water uses shown all appear to have very dependable supplies. This is not entirely unexpected as water uses tend to develop where the supply is. If there are any areas where supply is less dependable, observation of the data suggests it would be in the headwaters of the Basin. This would only be logical, as the further one moves toward the upper reaches of the Basin, the less drainage area contributes to the runoff, and the more vulnerable the system is to the extremes of prairie hydrology.

Prairie hydrology dictates that the majority of flow still occurs with spring runoff. Making that supply available for use at other times and away from the major streams often requires some type of storage and infrastructure.

Although not specifically investigated, it can be assumed that there remains draft available out of Lake of the Prairies. The addition of the ski hill withdrawal and increases in upstream municipal withdrawals in the future use estimates does not appear to have a measurable effect on Lake of the Prairies elevations. It can thus be assumed that draft out of the reservoir is available, the magnitude of which would require a specific study as it impacts the sustainable yield of the entire Assiniboine River system to Winnipeg.

Although there are shortcomings in the instream flow analysis, the results suggest that during periods of low flow, water diverted for offstream use could impact the aquatic ecology, and that both uses should be considered when allocating water and operating reservoirs. The results of the instream flow analysis also suggest that the operation of the reservoirs have augmented the minimum flows to some degree and thus have dampened that extreme of prairie hydrology.

Groundwater supply was characterized by presenting 16 cross-sections showing the Basin geology and maps of known regional aquifers. Where known, production capabilities and water quality were also indicated. All information was based on data previously validated and interpreted.

Groundwater management is a combination of obtaining insight into the potential supply of an aquifer both directly through mapping and analysis and indirectly by examining the sustainability of groundwater uses. Borehole, geophysical, production and water quality data collection by the regulating agencies and others is ongoing. The validation, interpretation and mapping of that data continues in Saskatchewan and Manitoba as resources permit. A detailed aquifer management approach to groundwater management has been necessary only for the Yorkton aquifer system to date. In the majority of the Basin, the protection of other aquifers and the sustainability of uses are reliant on the regulatory process.

The work of the Committee has provided a basic inventory of water withdrawal uses and recognition of the instream uses of water. An inventory of water supply on a regional basis has also been provided, sufficient to assess water supply and the effect of new uses on the system or other users on a regional basis or as a first step in detailed site specific analysis. The current groundwater mapping is provided. Much more work needs to be done to develop a good inventory of groundwater resources, including aquifer location, production capability and water quality, and the role of wetlands in the hydrogeology of the Basin.

7. Conclusions and Recommendations

The surface water supply was characterized for 23 watersheds by estimating mean monthly natural flows over the historical period of 1941-1995 inclusive. Although it may have been possible to isolate the effect of drainage on the historical record, the assumptions that would be made would render the results technically indefensible. A predictive approach based on some assumed level of future suitable methodologies to create climate scenarios for the Prairies has yet to be developed.

Groundwater supply was characterized by the preparation of 16 cross-sections illustrating the geology of the Basin and regional aquifer maps on a 1:50,000 scale. All work was based on previously verified and interpreted data, therefore the maps are not necessarily based on the most recent data. Production capabilities and water quality were indicated where known, but for most aquifers these properties have not been defined. A detailed aquifer management plan is currently being developed for only one area in the Basin, the Yorkton aquifer system. No further aquifer management plans are currently envisioned, however that could change at any time with additional use. Management of all other groundwater resources in the Basin is reliant on the regulatory process in order to licence withdrawals and to control land-use activities that may impact the quality of groundwater resources.

Recommendation 1.

Increased effort should be put into groundwater management, including:

- **Appropriate geological and hydrogeological mapping, at least to the extent that all the data that are currently available are used;**
- **Aquifer characterization and resource assessment, including aquifer production capabilities and water quality analysis, to define the groundwater supply and facilitate economic development and more proactive groundwater management; and**
- **Where necessary, provide more effective groundwater management through the regulatory process by ensuring adequate data collection and providing timely analysis of water quality and water level data.**

Water use in the Basin is approximately 62,000 dam^3/y, of which roughly 80 percent is supplied by surface water and 20 percent by groundwater. Surface water is used primarily for reservoir evaporation, wildlife conservation projects, agricultural uses (irrigation, livestock, crop spraying and some rural domestic use), and about 20 percent of municipal uses. Groundwater supplies 80 percent of the municipal uses, most of the industrial uses and much of the rural domestic use. Total water use is estimated to increase by 5 percent by 2010 and 7 percent by 2020 barring any major water use developments. All water use estimates except municipal uses are based on allocated volumes or simplified analysis, as there is essentially no recorded water uses.

Recommendation 2.

An enhanced water monitoring program should be implemented in the Basin to obtain data on actual surface water and groundwater usage and to ensure that all major usage is licensed and appropriately monitored. Efforts should also be made to improve the timely analysis of data where warranted.

Apportionment of water between Saskatchewan and Manitoba is currently not an issue. Saskatchewan uses only a small portion of its 50 percent entitlement at present. Since future water use projections to year 2020 indicate that Saskatchewan's water use will increase only marginally, apportionment, at least between Manitoba and Saskatchewan, will not be an issue in the future barring major unforeseen increases in use by Saskatchewan.

For the current level of water use, supply is generally sufficient to meet current and projected uses. Therefore there is presently no immediate need to examine other water supply scenarios or alter present water supply management practice. Surface water supply is less reliable in the headwaters of the Basin and, like all prairie areas, there are undoubtedly some problems with drought. As the supply appears to be available, remedies to supply shortages would most likely include some type of infrastructure, be it storage and/or transport of surface water or groundwater exploration and development. If a major unforeseen water intensive use is proposed for the Basin, the surface water supply-demand relationship will have to be closely re-examined.

Recommendation 3.

Surface water supplies should continue to be allocated subject to water availability and downstream demands.

Recommendation 4.

Measures should be taken to ensure the availability of adequate supplies of good quality water in all areas of the Basin. In particular, the expected expansion in livestock production will require a supply of good quality water that is available and dependable.

Measures may include:

- **Additional storage, when required and when sufficient water is available, should be developed only through off-channel storage;**
- **Water distribution systems that increase availability in water short areas;**
- **Water treatment technology that can increase the availability of good quality water;**
- **Encouragement of land management practices which have a positive effect on the availability of good quality water; and**
- **Examination and improvement of infrastructure as necessary to ensure safe and reliable water supplies.**

A preliminary analysis of instream flow needs suggests that water is available for aquatic ecosystems and offstream uses, but during periods of low flows there may be conflict. Instream flow needs should be considered in water management when granting allocations and operating dams.

Recommendation 5.

Instream flow needs should be an integral part of future water management, particularly when changing the operating guidelines for a dam and when granting new water allocations.

Recommendation 6.

Instream flow guidelines should be established with due consideration for other uses and dam operations.

a) **Additional investigations should be conducted to customize the Tessmann method for use in the Upper Assiniboine River Basin.**

b) **Projects that propose to use a major portion of the available water supply may require a more detailed study involving alternate instream flow assessment methodologies.**

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Appendix I

Water Supply and Use Committee
Terms of Reference

Water Supply and Use Committee
Terms of Reference

Overall Goal

To characterize the current relationship between water supply and water demand in the basin. To employ the characterization to examine water management strategies for current conditions and possible future scenarios.

Terms of Reference

1. Characterize the current water supply in time and space - hydrologically on a sub-basin level and hydrogeologically on an mappable aquifer unit level and non-mapped units of significant importance.

2. On a sub-basin level, characterize the historical and current water demand in time and space:
    - municipal
    - domestic
    - livestock
    - industrial
    - irrigation
    - fisheries
    - wildlife
    - recreation
    - downstream demands
    - "off-basin" aquifer demands
    - "other" demands

3. Construct a model to describe the physical relationship between supply and demand in the basin.

4. Examine future changes in water supply and demand based on technological change, physical environmental change, economics, demographics, etc.

5. Develop potential management strategies using the physical model, for both the present and the future for decision makers. Frame these new strategies within their technical, economic, sociological, environmental, and financial feasibilities.

Appendix II

Natural Flow Estimates

Upper Assiniboine River Basin Study - Natural Flow Determination

Monthly natural flows were required for each of the 23 sub-basins listed in Section 2.1 of the main report. The term "aggregated spatial area" (ASA) is synonymous with sub-basin.. For purposes of this study, natural flows developed in previous studies were used as published, and recorded flows were used directly where basin water uses were known to be small relative to the flows. Insufficient information was available to facilitate meaningful estimation of the magnitude of historic drainage volumes, so it was not possible to adjust the published natural or recorded flows for the effects of agricultural drainage. For that reason, the flows provided for water supply modelling purposes are termed "pseudo-natural flows." The pseudo-natural flows inherently reflect the net effect of historic landcover changes in the basin which include bush clearing, agricultural drainage and cultivation practices.

A review of available hydrometric data for the Upper Assiniboine River Basin identified 24 flow gauging stations, as shown in Table II.1, and seven water level gauging stations with periods of record ranging from two to 74 years over the period 1913-96. Monthly recorded flow arrays were compiled for each of the 24 flow gauging stations, and were assigned an A-File name as listed in Table II.2. (By convention, recorded flow arrays are termed "A-Files".)

Selection of Key Base Stations and Period of Record

Six stations, identified on Figure 1 and denoted as ASIN A1 to ASIN A6 in Table II.2, for which monthly natural flows are available or could be readily estimated for the period 1941-95, were selected as key base stations. This 55-year period contains a representative sequence of critical low and high runoff years necessary for water supply modelling purposes. Adoption of this study period eliminates the need for extensive data estimation in earlier years when minimal recorded data was available. At the time of this work, hydrometric data more recent than 1995 was not yet available from Environment Canada. These six stations were subsequently used to estimate missing monthly natural flows at all 23 ASAs using effective drainage area and runoff ratios. The recorded monthly flows for the six key base stations are provided in Tables A-1 to A-6.

Table II.1 - Hydrometric (Flow) Gauging Stations Within the UARB

STATION NUMBER	STATION NAME	PERIOD OF MONTHLY RECORD*	NATURAL GROSS DRAINAGE AREA (km^2)	NATURAL EFFECTIVE DRAINAGE AREA (km^2)
05MB001	YORKTON CREEK NEAR EBENEZER	1941-96+	2317.0	410.0
05MB002	WHITESAND RIVER NEAR KAMSACK	1941-42	9664.0	2340.3
05MB003	WHITESAND RIVER NEAR CANORA	1943-96+	8744.3	2002.3
05MB004	WHITESAND RIVER NEAR SHEHO	1957-73	1845.9	270.1
05MB005	WILLOW BROOK AT WILLOWBROOK	1964-92	402.0	95.3
05MB006	CROOKED HILL CREEK NEAR CANORA	1956-60; 1962-92	582.0	104.4
05MB007	SPIRIT CREEK NEAR BUCHANAN	1957-92	259.8	103.6
05MB008	WHITESAND RIVER NEAR SPRINGSIDE	1966; 1971-94	2652.7	655.5
05MB011	VAN PATTENS CREEK NEAR KUROKI	1962-87	113.2	85.0
05MB012	LAWRIE CREEK NEAR INSINGER	1964; 1966-67; 1969-85	190.4	109.3
05MC001	ASSINIBOINE RIVER AT STURGIS	1944-63; 1965-96+	1928.2	1143.0
05MC002	STONY CREEK NEAR STENEN	1957-92	253.6	153.3
05MC003	LILIAN RIVER NEAR LADY LAKE	1965-96+	229.0	152.6
05MC004	CONJURING CREEK NEAR PREECEVILLE	1965-67; 1969-92	255.6	143.5
05MD001	SHELL RIVER AT ASESSIPPI	1914-21	2004.1	1131.6
05MD002	SHELL RIVER NEAR DUCK LAKE	1920-32	1679.9	895.9
05MD004	ASSINIBOINE RIVER AT KAMSACK	1944-96+	12953.6	4323.7
05MD005	SHELL RIVER NEAR INGLIS	1948-95+	1999.0	1126.4
05MD006	LITTLE BOGGY CREEK NEAR COTE	1957-73	248.4	126.7
05MD007	SHELL RIVER NEAR ROBLIN	1962-95+	1329.7	751.4
05MD010	STONY CREEK NEAR KAMSACK	1971-96+	460.8	115.8
05ME001	ASSINIBOINE RIVER NEAR RUSSELL	1913-32; 1942-95+	19298.0	7664.3
05ME005	CONJURING CREEK NEAR RUSSELL	1959-95+	88.1	59.3
05ME007	SMITH CREEK NEAR MARCHWELL	1975-96+	436.2	57.8

* Records may be very sparse in some years
+ Station operated for years beyond period indicated in data base

Note: other stations (provincial) in the basin didn't have readily available data (i.e. HYDAT CD)

Table II.2 - A-Files - Recorded Flow Arrays for Hydrometric Gauging Stations

ASIN A1	Yorkton Creek near Ebenezer (05MB001)
ASIN A2	Whitesand River near Canora (05MB003)
ASIN A3	Assiniboine River at Sturgis (05MC001)
ASIN A4	Assiniboine River at Kamsack (05MD004)
ASIN A5	Shell River near Inglis (05MD005)
ASIN A6	Assiniboine River near Russell (05ME001)
ASIN A7	Spirit Creek near Buchanan (05MB007)
ASIN A8	Whitesand River near Kamsack (05MB002)
ASIN A9	Whitesand River near Sheho (05MB004)
ASIN A10	Willow Brook at Willowbrook (05MB005)
ASIN A11	Crooked Hill Creek near Canora (05MB006)
ASIN A12	Whitesand River near Springside (05MB008)
ASIN A13	Van Pattens Creek near Kuroki (05MB011)
ASIN A14	Lawrie Creek near Insinger (05MB012)
ASIN A15	Stony Creek near Stenen (05MC002)
ASIN A16	Lilian River near Lady Lake (05MC003)
ASIN A17	Conjuring Creek near Preeceville (05MC004)
ASIN A18	Shell River at Asessippi (05MD001)
ASIN A19	Shell River near Duck Lake (05MD002)
ASIN A20	Little Boggy Creek near Cote (05MD006)
ASIN A21	Shell River near Roblin (05MD007)
ASIN A22	Stony Creek near Kamsack (05MD010)
ASIN A23	Conjuring Creek near Russell (05ME005)
ASIN A24	Smith Creek near Marchwell (05ME007)

Note: ASIN A1 to ASIN A6 were selected as key base stations. Pseudo-natural flows developed for these stations were subsequently used as the basis for estimation of missing monthly data for all ASAs.

Table A-1

RECORDED FLOWS (m^3/s)
YORKTON CREEK NEAR EBENEZER (05MB001) ASIN A1

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	.000	.934	.029	.000	.000	.000	.000	.000	-	-	-
1942	-	-	-	3.090	.266	.027	.004	.249	.000	.000	-	-	-
1943	-	-	.000	3.010	.336	.178	.052	.022	.000	.000	-	-	-
1944	-	-	.000	.706	.018	.031	.001	.006	.009	-	-	-	-
1945	-	-	.682	.470	.026	.009	.094	.000	-	-	-	-	-
1946	-	-	1.330	.212	.013	.000	.010	-	-	-	-	-	-
1947	-	-	-	-	1.140	.160	.085	.000	.002	.005	.002	-	-
1948	-	-	-	5.620	5.240	.094	.209	.024	.000	-	-	-	-
1949	-	-	-	2.270	.031	.902	.068	.008	.000	.000	-	-	-
1950	-	-	-	3.240	.126	.012	.033	.007	.000	.000	-	-	-
1951	-	-	-	-	.551	.042	.043	.028	.028	.039	-	-	-
1952	-	-	-	1.310	.013	.015	.000	.000	.000	.000	-	-	-
1953	-	-	-	3.020	.143	1.310	2.990	.756	.386	.321	-	-	-
1954	-	-	-	2.180	2.100	6.980	6.130	2.680	2.510	2.730	2.110	-	-
1955	-	-	-	12.600	16.100	7.140	3.640	1.200	.156	.177	-	-	-
1956	-	-	-	10.100	20.100	7.020	2.210	.882	.891	.287	-	-	-
1957	-	-	.000	6.570	2.680	.410	.195	.138	.110	.005	-	-	-
1958	-	-	.078	.129	.009	.001	.000	.000	.000	.000	-	-	-
1959	-	-	.766	.323	.016	.022	.038	.000	.017	.049	-	-	-
1960	-	-	.000	8.180	.144	.078	.009	.000	.000	.000	-	-	-
1961	-	-	.001	.030	.005	.000	.000	.000	.000	.000	-	-	-
1962	-	-	.000	1.580	.173	.087	.000	.000	.000	.005	-	-	-
1963	-	-	.190	.141	.053	.041	.048	.023	.032	.016	-	-	-
1964	-	-	.000	1.010	.063	.000	.000	.025	.005	.003	-	-	-
1965	-	-	.000	3.140	.255	.112	.058	.056	.063	.050	-	-	-
1966	-	-	.000	5.090	.541	.088	.069	.033	.024	.034	-	-	-
1967	-	-	.000	.789	.622	.027	.009	.004	.002	.031	-	-	-
1968	-	-	.150	.598	.088	.073	.067	.041	.047	.034	-	-	-
1969	-	-	.000	2.890	.126	.031	.071	.070	.051	.072	-	-	-
1970	-	-	.000	2.150	.642	.048	.235	.017	.027	.065	-	-	-
1971	-	-	.003	3.520	.187	.383	.245	.017	.002	.031	-	-	-
1972	-	-	.169	6.660	.329	.074	.039	.017	.015	.023	-	-	-
1973	-	-	.198	.094	.028	.235	.158	.445	.170	.066	-	-	-
1974	-	-	.042	8.310	3.000	.492	.391	.364	.272	.168	-	-	-
1975	-	-	.000	5.850	5.360	2.990	1.420	.699	.526	.408	-	-	-
1976	-	-	.114	11.200	3.360	2.920	1.390	.413	.192	.073	-	-	-
1977	-	-	.030	.643	.314	.134	.040	.038	.123	.079	-	-	-
1978	-	-	.042	1.200	.169	.081	.015	.063	.099	.085	-	-	-
1979	-	-	.006	5.210	2.230	.109	.582	.372	.268	.206	-	-	-
1980	-	-	.045	5.610	.326	.153	.126	.163	.076	.043	-	-	-
1981	-	-	.089	.076	.109	.237	.413	.432	.161	.224	-	-	-
1982	-	-	.062	1.000	.124	.074	.391	.112	.160	.139	-	-	-
1983	-	-	.015	3.400	1.200	1.680	2.260	.124	.075	.125	-	-	-
1984	-	-	.687	.427	.323	.178	.031	.049	.092	.131	-	-	-
1985	-	-	.011	7.140	2.100	.717	.056	.047	.066	.046	-	-	-
1986	-	-	1.390	2.270	.457	.158	.109	.061	.046	.040	-	-	-

1987	-	-	.840	.662	.082	.152	.228	.152	.066	.106	-	-	-
1988	-	.067	.186	1.210	.600	.034	.033	.117	.032	.038	-	-	-
1989	-	-	.020	.320	.141	.197	.171	.032	.074	.102	-	-	-
1990	-	-	.018	3.690	.301	.113	.060	.034	.030	.030	-	-	-
1991	-	-	.045	1.020	.249	.148	.165	.138	.052	.061	-	-	-
1992	-	-	.146	2.290	.506	.078	.900	.150	.221	.098	-	-	-
1993	-	.032	.246	.189	.205	.152	.987	.325	.446	.147	-	-	-
1994	-	-	.927	.668	.299	.659	1.520	.237	.199	.147	-	-	-
1995	-	-	.625	17.400	19.400	3.510	.299	.336	.050	.656	-	-	-
1996	-	-	.023	4.430	2.560	.507	.328	.275	.136	.186	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	-	.032	.000	.030	.005	.000	.000	.000	.000	.000	.002	-	-
MAX	-	.067	1.390	17.400	20.100	7.140	6.130	2.680	2.510	2.730	2.110	-	-
MEAN	-	.050	.204	3.257	1.707	.734	.513	.209	.148	.142	1.056	-	-

Table A-2

RECORDED FLOWS (m^3/s)
WHITESAND RIVER NEAR CANORA (05MB003) ASIN A2

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	.000	12.500	2.230	1.550	.627	-	-	-	-	-	-
1944	-	-	-	1.120	.328	.272	.035	.000	.000	.000	-	-	-
1945	-	-	.520	1.270	.454	.321	.246	.001	.028	.075	-	-	-
1946	-	-	1.490	2.750	.425	.123	.054	.003	.055	.172	-	-	-
1947	-	-	-	12.100	8.280	1.620	1.070	.126	.109	.147	-	-	-
1948	-	-	-	27.200	23.900	.936	.726	.130	.004	.007	-	-	-
1949	-	-	-	1.370	.160	.880	.081	.070	-	-	-	-	-
1950	-	-	-	8.230	2.170	.328	.190	.144	-	-	-	-	-
1951	-	-	-	8.890	8.820	.988	.380	.063	.186	.395	-	-	-
1952	-	-	-	9.710	1.110	.233	.022	.000	.000	.000	-	-	-
1953	-	-	-	8.180	2.930	6.870	20.300	8.940	2.880	1.460	1.430	-	-
1954	-	-	-	19.000	13.800	48.500	17.500	5.730	6.480	7.730	4.320	-	-
1955	-	-	-	50.400	74.600	20.600	10.700	4.010	.882	.982	-	-	-
1956	-	-	-	36.900	64.600	17.600	6.760	1.930	1.380	.817	-	-	-
1957	-	-	.000	23.000	14.100	2.480	.858	.408	.185	.000	-	-	-
1958	-	-	.247	3.240	.724	.126	.000	.000	.000	.000	-	-	-
1959	-	-	.521	1.900	.131	.081	.286	.000	.000	.051	-	-	-
1960	-	-	.106	19.700	3.990	1.770	.743	.003	.000	.000	-	-	-
1961	-	-	.000	.181	.058	.000	.000	.000	.000	.000	-	-	-
1962	-	-	.000	7.990	1.720	.130	.000	.000	.000	.000	-	-	-
1963	-	-	.259	.575	.038	.062	.019	.001	.000	.000	-	-	-
1964	-	-	.000	.858	.580	.049	.000	.000	.000	.350	-	-	-
1965	-	-	.000	7.840	2.270	2.090	.311	.121	.066	.186	-	-	-
1966	-	-	.000	17.800	6.480	1.920	1.700	1.340	.138	.323	-	-	-
1967	-	-	.008	3.770	12.300	1.140	.026	.005	.008	.586	-	-	-
1968	-	-	.580	1.920	.208	.136	.003	.002	.153	.000	-	-	-
1969	-	-	.000	9.000	1.170	.117	.127	.131	.021	.285	-	-	-
1970	-	-	.000	10.500	9.140	1.590	1.640	.075	.000	.754	-	-	-
1971	-	-	.071	24.500	3.390	2.490	1.710	.210	.000	.039	-	-	-
1972	-	-	.174	27.800	7.130	.414	.044	.001	.000	.000	-	-	-
1973	-	-	.372	.426	.319	1.710	.710	.001	.337	.005	-	-	-
1974	-	-	.060	24.800	21.400	8.020	.725	.579	.513	.336	-	-	-
1975	-	-	.113	24.300	41.400	8.110	3.160	1.140	1.000	.736	-	-	-
1976	-	-	.303	52.500	12.900	11.200	9.170	1.850	.580	.207	-	-	-
1977	-	-	.085	1.710	1.530	.109	.000	.000	.000	.000	-	-	-
1978	-	-	.000	3.350	.509	.032	.635	.066	.001	.006	-	-	-
1979	-	-	.005	22.500	28.300	3.700	.842	.381	.503	.326	-	-	-
1980	-	-	.003	12.100	1.990	.294	.082	.044	.019	.036	-	-	-
1981	-	-	.261	.190	.173	.856	.683	.428	.019	.642	-	-	-
1982	-	-	.059	4.060	1.140	.432	1.800	.151	.014	.060	-	-	-
1983	-	-	.076	13.300	9.890	3.290	6.690	1.100	.039	.025	-	-	-
1984	-	-	1.280	3.250	1.980	.989	.258	.000	.000	.208	-	-	-
1985	-	-	.060	37.000	10.900	3.600	.925	.269	.143	.190	-	-	-
1986	-	-	1.720	21.400	5.840	2.060	1.380	.359	.008	.006	-	-	-

1987	-	-	.751	6.100	1.500	.364	.795	.022	.004	.001	-	-	-
1988	-	.448	.574	9.630	8.480	2.030	.004	.001	.000	.000	-	-	-
1989	-	-	.000	.390	.103	.295	.024	.000	.000	.000	.162	-	-
1990	-	-	.000	21.100	4.720	.076	.027	.000	.000	.003	.120	-	-
1991	-	-	.000	2.140	.407	.101	.066	.018	.000	.000	.048	.046	-
1992	-	-	.078	5.610	2.830	.061	.916	.022	.386	.070	-	-	-
1993	-	.044	.398	.478	.190	.328	4.460	.467	.474	.199	-	-	-
1994	-	-	2.970	6.220	2.490	2.900	7.220	.504	.371	.319	-	-	-
1995	-	-	1.180	76.400	51.700	12.900	1.380	2.810	2.970	3.820	-	-	-
1996	-	-	.136	23.600	14.700	2.870	1.240	.922	.061	.247	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	-	.044	.000	.181	.038	.000	.000	.000	.000	.000	.048	.046	-
MAX	-	.448	2.970	76.400	74.600	48.500	20.300	8.940	6.480	7.730	4.320	.046	-
MEAN	-	.250	.336	13.569	9.123	3.366	2.025	.652	.392	.427	1.216	.046	-

Table A-3

RECORDED FLOWS (m³/s)
ASSINIBOINE RIVER AT STURGIS (05MC001)

ASIN A3

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	.806	.553	.181	.083	.028	.019	.020	-	-	-
1945	-	-	.213	2.430	1.650	.973	.706	.107	.116	.143	.038	-	-
1946	-	-	1.050	4.050	1.260	.766	.362	.043	.232	.228	-	-	-
1947	-	-	-	3.130	4.720	1.610	2.270	.410	.474	.527	-	-	-
1948	-	-	-	8.020	20.900	1.770	.523	.267	.048	.073	-	-	-
1949	-	-	-	1.020	1.330	3.960	.806	.199	.031	.044	.004	-	-
1950	-	-	-	3.620	3.440	1.110	.482	2.100	.186	.166	-	-	-
1951	-	-	-	6.620	14.000	3.430	1.670	.955	3.550	6.680	-	-	-
1952	-	-	.119	18.900	6.230	1.850	.446	.232	.085	.187	-	-	-
1953	-	-	-	4.300	9.460	16.300	26.600	14.800	7.010	1.960	1.680	-	-
1954	-	-	-	6.260	29.100	44.600	5.640	2.180	5.060	3.700	1.750	-	-
1955	-	-	-	26.800	36.000	4.600	1.130	.338	.216	.259	-	-	-
1956	-	-	-	4.380	32.300	5.980	1.590	.600	.632	.597	-	-	-
1957	-	-	.133	12.800	9.230	.916	.364	.199	.261	.221	-	-	-
1958	-	-	.153	1.890	.631	.299	.104	.000	.000	.000	-	-	-
1959	-	-	.149	.888	.426	.029	.109	.030	.139	.516	-	-	-
1960	-	-	.000	17.200	6.870	5.810	1.790	.044	.005	.000	-	-	-
1961	-	-	.037	.305	.481	.029	.000	.000	.000	.000	-	-	-
1962	-	-	.000	5.100	1.790	.185	.000	.000	.000	.000	-	-	-
1963	-	-	.209	3.450	.444	.367	.133	.000	.000	.000	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	.000	9.250	5.730	19.700	4.240	.594	.352	.380	.291	-	-
1966	-	-	.668	18.600	9.900	3.880	2.400	2.170	.538	.323	-	-	-
1967	-	-	.233	3.990	16.400	2.530	.156	.000	.000	.000	-	-	-
1968	-	-	.201	3.220	.232	.161	.209	.332	.085	.216	-	-	-
1969	-	-	.082	8.020	1.340	.254	.114	.010	.002	.150	-	-	-
1970	-	-	.027	7.250	12.400	2.840	1.350	.671	.122	.232	-	-	-
1971	-	-	.294	22.500	4.190	2.390	.685	1.020	.043	.160	-	-	-
1972	-	-	.202	26.000	28.100	1.510	.434	.140	.040	.490	-	-	-
1973	-	-	.345	4.290	3.860	5.360	5.920	.530	.058	.197	-	-	-
1974	-	-	.190	15.700	29.800	10.700	.922	.125	.786	.948	-	-	-
1975	-	-	.327	15.900	22.000	5.660	1.710	.180	.285	.494	-	-	-
1976	-	-	.172	30.000	4.680	8.590	6.320	.656	.411	.106	-	-	-
1977	-	-	.146	4.460	1.180	.182	.023	.016	.042	.047	-	-	-
1978	-	-	.056	6.930	2.600	.170	1.510	.141	.107	.139	-	-	-
1979	-	-	.154	16.000	32.500	6.590	.533	.090	.015	.063	-	-	-
1980	-	-	.132	6.820	.668	.115	.062	.062	.063	.163	-	-	-
1981	-	-	.837	3.530	.883	.241	.139	.267	.065	.834	-	-	-
1982	-	-	.106	5.300	1.690	.457	.141	.078	.035	.166	-	-	-
1983	-	-	.050	7.240	5.870	2.390	1.490	.566	.046	.086	-	-	-
1984	-	-	.829	6.610	3.020	4.700	.327	.062	.003	.179	-	-	-

1985	-	-	.107	18.800	5.180	.512	.049	.020	.007	.126	-	-	-
1986	-	-	.594	13.300	2.250	.458	.559	.027	.009	.116	-	-	-
1987	-	-	.271	10.400	1.090	.380	.170	.143	.020	.119	-	-	-
1988	-	-	.210	15.100	8.710	.861	.018	.004	.000	.003	-	-	-
1989	-	-	.021	1.250	.290	.412	.370	.058	.224	.312	-	-	-
1990	-	-	.079	7.050	2.420	.427	.107	.014	.002	.001	-	-	-
1991	-	-	.028	1.250	.565	.136	.893	.004	.000	.005	-	-	-
1992	-	-	.124	4.520	1.110	.063	.010	.008	.013	.013	-	-	-
1993	-	.042	.264	.922	.290	.136	5.430	12.000	6.290	1.900	-	-	-
1994	-	-	1.270	6.430	2.470	2.000	1.340	.266	.225	.151	-	-	-
1995	-	-	.371	31.500	23.100	6.210	7.040	9.430	2.220	1.430	-	-	-
1996	-	-	.298	16.900	15.800	3.760	1.690	.777	.075	.198	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	-	.042	.000	.305	.232	.029	.000	.000	.000	.000	.004	-	-
MAX	-	.042	1.270	31.500	36.000	44.600	26.600	14.800	7.010	6.680	1.750	-	-
MEAN	-	.042	.256	9.250	8.291	3.626	1.753	1.019	.582	.482	.753	-	-

Table A-4

RECORDED FLOWS (m^3/s)
ASSINIBOINE RIVER AT KAMSACK (05MD004) ASIN A4

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	2.560	1.400	.964	.472	.117	.139	.167	.160	-	-
1945	-	-	.745	6.430	4.050	2.370	1.300	.272	.308	.567	-	-	-
1946	-	-	3.270	13.800	3.150	1.160	.623	.269	.239	.383	.225	-	-
1947	-	-	-	21.600	18.100	4.910	4.820	.962	.832	1.120	-	-	-
1948	-	-	-	37.600	73.700	5.510	2.440	1.000	.259	.409	.600	-	-
1949	-	-	-	3.120	1.630	5.230	1.400	.472	.136	.176	.063	-	-
1950	-	-	-	14.100	9.570	2.360	1.000	2.250	.545	.325	.198	-	-
1951	-	-	-	20.400	32.100	6.470	3.060	1.240	3.230	7.870	.350	-	-
1952	-	-	-	37.400	12.200	3.440	1.230	.319	.199	.247	.212	-	-
1953	-	-	-	16.500	16.200	21.100	62.800	31.300	12.700	5.200	4.450	-	-
1954	-	-	-	31.200	63.700	118.000	38.800	9.450	12.200	13.500	7.810	-	-
1955	-	-	-	91.600	132.000	31.900	12.700	4.820	2.320	2.280	-	-	-
1956	-	-	-	42.400	125.000	29.400	10.900	3.130	2.300	1.770	1.890	.964	-
1957	.431	.375	.402	40.900	45.200	5.460	1.790	1.100	1.020	.147	.232	.333	256639
1958	.159	.298	.309	8.490	2.510	.674	.101	.029	.030	.081	.375	.066	34242
1959	.050	.028	1.090	5.630	1.600	.477	.560	.154	.212	.620	.528	.200	29263
1960	177	.201	.131	53.700	19.300	9.340	3.680	.163	.031	.021	.169	.219	227876
1961	.168	.083	.218	.626	.718	.359	.000	.000	.000	.000	.000	.000	5711
1962	.000	.000	.007	19.900	7.160	1.200	.250	.004	.053	.049	.083	.000	75051
1963	.000	.000	.913	6.440	1.480	1.150	.540	.075	.000	.028	.028	.028	27952
1964	.028	.028	.028	5.000	5.310	.812	.304	.349	.761	.705	.721	.277	37728
1965	.222	.192	.164	21.300	8.940	19.500	5.570	1.210	1.370	3.280	1.600	.643	167562
1966	.572	.378	.809	55.100	23.800	9.110	6.220	4.770	1.590	.473	.828	.724	273701
1967	.503	.399	.270	12.000	42.200	5.800	.570	.108	.007	.470	.161	.183	166202
1968	.146	.173	1.710	8.440	1.340	.755	.374	.332	.314	.073	.149	.143	36497
1969	.129	.076	.130	26.400	4.950	1.240	.628	.545	.118	.620	.346	.131	92134
1970	.077	.071	.073	20.900	27.600	6.180	3.700	.770	.043	.945	1.980	.773	166506
1971	.387	.320	.289	68.300	18.000	6.370	3.110	1.810	.156	.558	.916	.943	264317
1972	.609	.329	.754	64.200	60.200	3.790	.792	.226	.009	.066	.266	.148	345957
1973	.086	.088	.699	5.140	5.560	8.420	7.390	1.080	.217	.167	.399	.571	78614
1974	.354	.350	.336	47.500	68.400	30.000	2.140	1.170	1.610	1.800	1.690	1.520	413089
1975	.814	.721	.583	45.100	89.400	19.500	6.650	1.480	1.360	1.350	1.710	.833	447958
1976	.434	.403	.873	99.300	26.200	20.500	19.900	3.150	.484	.402	.693	.657	452830
1977	.407	.386	.493	9.940	4.340	.711	.157	.117	.146	.354	.461	.436	46999
1978	.266	.184	.269	15.700	6.910	.888	1.240	.130	.070	.177	.693	.573	71038
1979	.414	.311	.229	41.100	93.200	14.000	1.850	.483	.511	.330	.404	.460	405657
1980	.453	.374	.358	28.800	5.130	.629	.434	.115	.078	.264	.497	.319	97652
1981	.187	.181	1.790	4.700	1.750	1.480	1.250	.644	.122	1.400	1.630	.619	41461
1982	.215	.155	.342	9.210	4.290	1.440	5.150	.498	.053	.242	.344	.202	58308
1983	.243	.285	.296	25.500	35.100	8.170	11.300	2.760	.254	.180	.586	.621	225399
1984	.378	.367	4.530	15.400	7.410	8.430	2.100	.109	.064	.197	.787	.661	106100
1985	.351	.322	.341	76.800	28.100	6.570	1.450	.413	.321	.508	.540	.378	303585
1986	.373	.429	1.950	60.600	12.100	3.730	2.270	.690	.061	.179	.402	.443	217206

1987	.393	.393	1.750	28.800	4.500	1.610	1.940	.423	.167	.338	.701	.818	109241
1988	2.270	1.670	1.840	45.700	26.800	3.920	.340	.074	.028	.048	.202	.232	218044
1989	.160	.152	.188	2.550	1.000	.940	.618	.039	.090	.062	.452	.274	17089
1990	.262	.196	.240	41.100	10.900	1.780	.389	.080	.047	.012	.058	.149	144118
1991	.107	.135	.176	5.050	1.900	.510	1.220	.135	.015	.014	.193	.201	25329
1992	.139	.255	.287	18.900	7.360	.847	.784	.112	.238	.331	.342	.266	78179
1993	.217	.197	.996	2.260	1.370	.686	15.300	8.630	12.800	4.350	2.300	1.280	133344
1994	.909	.554	5.160	16.500	6.640	7.510	11.400	1.130	.601	.759	.825	.799	139043
1995	.622	.632	1.400	144.000	119.000	21.900	10.900	15.800	8.580	5.740	7.430	3.080	892322
1996	1.750	.828	.603	59.200	48.100	11.100	6.410	3.750	.379	.381	1.800	2.930	361154
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	.000	.000	.007	.626	.718	.359	.000	.000	.000	.000	.000	.000	5711
MAX	2.270	1.670	5.160	144.000	132.000	118.000	62.800	31.300	12.800	13.500	7.810	3.080	892322
MEAN	.387	.314	.882	30.281	26.011	9.062	5.327	2.080	1.310	1.165	.990	.588	182277

Table A-5

RECORDED FLOWS (m^3/s)
SHELL RIVER NEAR INGLIS (05MD005) ASIN A5

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	11.600	29.600	6.180	11.500	8.380	2.810	2.070	1.550	-	-
1949	-	-	.461	5.190	2.970	4.700	2.440	2.340	1.250	1.150	1.280	-	-
1950	-	-	-	-	9.850	6.620	5.710	3.440	1.290	2.220	-	-	-
1951	-	-	-	9.210	17.700	4.360	3.730	2.790	5.020	5.660	-	-	-
1952	-	-	-	10.300	5.640	3.660	1.920	1.140	1.810	2.010	1.370	-	-
1953	-	-	-	6.520	9.020	10.500	19.500	5.280	5.530	4.520	5.350	-	-
1954	-	-	-	6.820	15.000	30.200	14.000	3.230	5.230	6.730	4.270	-	-
1955	-	-	-	16.800	17.500	7.550	4.320	1.430	1.050	1.460	-	-	-
1956	-	-	1.080	4.780	14.400	6.520	7.130	2.750	2.470	1.950	1.760	1.330	-
1957	1.350	1.070	.930	9.160	15.100	3.920	2.080	1.400	1.170	1.310	1.360	.886	104803
1958	.419	.369	.748	4.020	2.210	1.580	1.010	.567	1.180	1.580	1.790	.686	42444
1959	.673	.446	1.510	5.480	6.040	4.380	5.250	1.090	1.410	2.680	2.470	1.720	87484
1960	.905	1.030	1.090	10.600	8.630	9.590	2.030	.652	.343	.528	1.020	.563	97010
1961	.728	.541	.503	1.480	1.380	.790	.407	.143	.122	.323	.829	.687	20829
1962	.822	1.020	1.030	2.330	2.450	1.330	.321	.386	.477	.847	.896	.368	32183
1963	.227	.236	.815	5.060	4.740	2.320	1.480	.701	.637	.849	.798	.624	48693
1964	.563	.555	.555	4.940	4.070	1.280	.612	.502	.471	.736	.556	.015	39066
1965	.001	.000	.000	5.690	9.140	6.170	2.060	1.640	1.600	3.190	1.430	.874	83873
1966	.949	.972	1.070	8.710	12.100	7.570	6.200	1.390	.576	.808	.888	.790	110769
1967	.780	.681	.716	1.870	9.180	5.210	1.520	.630	.284	.584	.804	.686	60574
1968	.659	.693	1.380	4.570	2.240	1.260	1.020	1.080	.908	.910	.945	.654	42925
1969	.799	.926	1.050	5.030	3.160	1.620	2.110	2.080	.941	2.210	1.620	.993	59333
1970	.785	.814	.807	7.130	18.700	3.710	2.770	3.560	.624	1.290	6.520	1.770	128084
1971	1.190	1.080	.936	15.400	7.940	4.270	2.780	1.890	.589	1.320	1.460	1.110	104886
1972	1.160	1.060	1.100	11.300	16.000	3.450	2.690	1.000	.655	.891	.916	.578	107685
1973	.292	.277	.758	4.680	2.290	3.300	3.900	1.010	1.690	1.750	1.470	1.220	59597
1974	.871	.796	.902	15.400	23.600	10.200	2.710	1.400	1.830	2.850	1.760	1.120	167187
1975	1.100	1.040	1.100	7.580	17.700	10.400	3.470	1.410	1.800	2.990	2.780	1.160	138478
1976	1.060	1.260	1.110	18.400	7.110	24.700	9.340	1.900	.935	1.010	.823	.499	178431
1977	.364	.497	.523	5.030	3.240	1.660	2.070	1.500	3.400	4.240	2.300	1.350	68905
1978	1.090	.745	1.340	6.380	6.880	3.450	1.570	.598	.818	1.390	1.410	.752	69536
1979	.523	.499	.568	11.800	21.700	11.900	2.090	.752	.902	.835	1.560	.805	142067
1980	.745	.753	.889	8.220	3.290	1.020	.832	.967	.886	1.180	1.230	.530	53908
1981	.338	.423	2.970	4.370	2.660	1.950	1.440	.867	.585	1.290	1.330	.504	49337
1982	.217	.371	.373	4.980	3.870	1.880	4.100	2.480	.492	1.200	1.340	.699	58083
1983	.819	.831	.748	7.590	12.200	7.650	6.340	1.930	.714	1.280	1.560	.963	112438
1984	.586	.707	4.640	7.930	7.390	6.470	5.930	.757	.766	2.240	1.200	2.000	107250
1985	1.140	.854	1.030	11.500	6.350	4.550	2.300	4.340	2.500	3.150	1.840	1.400	107708
1986	1.520	1.190	1.960	12.600	10.100	3.550	2.560	1.560	.741	3.120	1.570	1.220	109762
1987	1.070	.785	.981	12.300	3.320	3.060	4.130	1.900	1.000	1.840	2.010	1.510	89023

1988	.692	.720	.709	13.600	27.700	4.330	1.670	.811	.420	.724	.741	.673	139619
1989	.600	.612	.579	3.010	1.780	2.710	2.280	.770	1.220	1.600	2.090	1.190	48454
1990	.847	.976	1.440	11.900	17.600	5.540	2.340	.803	.554	.720	.832	.622	116436
1991	.523	.584	.717	4.150	3.450	3.590	5.770	1.510	.652	.731	1.090	.913	62454
1992	.868	.838	.952	6.790	4.640	2.100	1.070	.645	.996	1.490	1.270	1.020	59635
1993	.879	.450	1.070	3.280	2.350	1.200	7.140	2.880	3.800	2.390	1.750	1.340	75429
1994	1.030	.923	1.670	7.270	2.700	4.160	18.600	8.160	4.030	2.020	1.520	1.160	140900
1995	1.190	.843	1.370	19.800	32.500	9.230	3.470	4.840	2.400	1.740	1.610	1.200	211716
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	.001	.000	.000	1.480	1.380	.790	.321	.143	.122	.323	.556	.015	20829
MAX	1.520	1.260	4.640	19.800	32.500	30.200	19.500	8.380	5.530	6.730	6.520	2.000	211716
MEAN	.779	.731	1.078	8.139	9.775	5.570	4.161	1.943	1.491	1.867	1.666	.955	90692

Table A-6

RECORDED FLOWS (m^3/s)
ASSINIBOINE RIVER NEAR RUSSELL (05ME001) ASIN A6

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	1.550	2.830	136.000	128.000	52.500	96.500	72.200	29.900	16.900	14.300	6.000	-
1914	2.850	2.680	3.810	49.200	103.000	33.500	10.200	3.560	3.340	4.080	3.710	2.090	586209
1915	1.270	1.780	1.840	16.700	7.000	7.280	10.500	4.230	3.360	3.950	3.680	2.120	167499
1916	1.420	1.420	1.270	40.900	23.800	51.600	26.400	11.100	7.550	9.880	9.370	3.180	493545
1917	1.310	1.070	1.470	25.200	112.000	31.200	42.400	10.800	7.800	4.860	5.140	1.670	649725
1918	1.550	1.410	4.200	30.500	12.800	13.500	15.200	9.780	6.630	6.270	5.540	3.080	290638
1919	2.380	2.150	1.980	27.400	19.900	11.300	28.000	8.180	7.600	8.460	4.880	2.680	329580
1920	2.650	2.660	2.790	36.000	152.000	36.900	11.200	5.700	4.710	5.290	7.290	3.720	717810
1921	2.430	2.180	2.760	86.800	91.600	76.000	89.500	35.800	29.800	41.400	42.600	14.900	1360552
1922	8.150	5.200	5.450	185.000	323.000	95.200	24.300	12.600	9.940	6.140	9.150	4.870	1818211
1923	3.610	3.720	3.600	58.600	187.000	58.600	57.700	24.100	9.300	8.880	6.720	4.190	1128578
1924	2.520	2.300	2.760	21.800	25.900	16.400	9.560	13.700	8.200	9.180	6.420	4.070	323973
1925	3.000	2.440	3.530	109.000	33.200	30.800	21.000	7.760	5.170	5.870	4.150	2.630	598632
1926	1.710	1.790	3.590	51.500	23.800	14.600	6.130	3.250	6.730	11.000	9.710	3.950	361381
1927	3.100	2.540	2.620	119.000	134.000	49.900	33.800	18.400	18.600	20.400	11.800	5.210	1105363
1928	3.710	2.960	23.600	87.200	46.900	30.600	36.000	10.600	4.890	4.520	3.010	2.490	675584
1929	2.210	1.910	2.270	30.300	23.200	12.100	6.700	3.660	3.240	3.860	3.980	3.140	253871
1930	2.040	1.620	2.790	26.900	14.300	10.500	6.720	3.340	2.850	3.380	3.270	2.150	209717
1931	1.970	1.670	2.630	24.500	6.900	4.830	3.630	2.820	2.710	3.060	2.090	.921	151245
1932	.650	1.080	1.320	25.300	10.200	5.620	7.440	4.040	3.350	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	5.240	6.950	6.620	6.160	-	-	-	-
1943	-	-	-	-	22.400	17.300	8.320	3.930	2.640	2.830	-	-	-
1944	-	-	-	-	6.700	4.920	3.240	1.540	2.350	2.400	-	-	-
1945	-	-	6.100	19.100	16.800	8.970	8.310	3.520	3.200	4.150	-	-	-
1946	-	-	5.280	39.800	12.300	5.470	7.090	2.100	1.980	3.540	3.380	-	-
1947	-	-	-	50.300	51.400	28.100	35.100	7.510	7.340	7.470	-	-	-
1948	-	-	-	47.200	157.000	18.800	18.400	13.100	4.430	3.260	-	-	-
1949	-	-	-	14.200	6.920	13.900	6.250	4.720	2.460	2.710	2.470	-	-
1950	-	-	-	23.700	29.000	12.000	8.680	7.260	3.100	4.070	3.920	2.140	-
1951	1.500	1.640	1.600	36.400	57.200	14.700	9.470	6.560	9.880	13.400	10.100	4.000	439253
1952	1.920	1.690	1.980	54.800	21.800	8.970	4.770	2.780	3.420	3.570	2.450	1.820	288235
1953	1.520	1.740	2.660	34.600	28.100	33.600	76.500	44.700	20.800	12.800	12.400	5.850	728071
1954	3.810	3.090	3.120	39.100	84.600	129.000	92.900	16.800	19.600	23.800	22.500	8.800	1178604
1955	3.660	3.340	3.240	114.000	171.000	66.900	22.000	9.800	4.120	4.620	4.520	2.910	1081197
1956	3.150	1.480	2.760	28.000	187.000	61.000	25.100	10.600	7.290	6.110	7.580	3.980	912273
1957	3.090	4.510	5.270	47.900	94.300	14.300	6.840	3.810	2.830	3.100	2.820	2.170	504382
1958	1.850	1.840	2.510	16.800	6.540	3.320	2.180	1.330	2.260	2.420	3.070	1.570	119700
1959	1.440	1.100	3.030	23.500	10.400	7.030	7.260	2.340	2.490	3.930	4.600	3.440	185452
1960	2.480	1.780	2.820	62.600	47.700	22.000	7.750	1.800	1.130	1.760	1.710	1.290	406807
1961	1.220	1.080	2.130	4.840	4.830	2.350	.957	.352	.582	1.560	1.510	1.420	60069
1962	.966	.586	2.250	28.000	24.100	5.080	1.610	1.280	1.590	1.610	2.130	2.110	187671
1963	.968	.916	3.550	16.600	7.210	5.470	4.820	1.710	1.520	2.410	1.760	1.480	127244
1964	1.700	1.790	2.500	12.000	11.900	3.710	1.660	1.480	1.070	2.100	2.320	1.470	115087
1965	1.350	1.270	1.410	35.300	23.300	29.400	9.750	4.570	3.550	4.760	3.050	2.300	314945
1966	2.850	2.040	2.930	67.600	52.800	18.000	16.800	7.490	3.410	2.450	3.000	2.300	478106
1967	2.320	1.700	2.330	12.500	57.300	14.100	3.820	1.810	.510	1.220	1.740	1.480	267130
1968	1.280	1.490	5.780	23.200	5.450	3.600	2.330	1.700	.233	.235	.367	.550	121157
1969	.616	.756	.917	14.100	16.800	2.020	2.000	2.090	1.840	1.780	3.860	4.440	135104
1970	4.170	3.690	3.820	21.800	48.500	15.700	10.300	4.030	2.580	1.830	2.650	3.800	324447
1971	3.610	3.590	3.770	5.770	16.500	6.450	12.800	7.840	1.730	4.490	11.700	12.800	240722
1972	12.600	13.500	13.400	13.800	78.300	46.900	2.910	2.260	3.660	5.230	13.500	15.000	583027
1973	12.600	9.350	5.610	1.750	1.530	1.390	1.300	1.600	4.370	6.340	9.770	9.480	170421
1974	8.960	8.900	20.400	26.100	60.700	55.400	48.200	13.900	6.010	6.030	11.600	13.800	739082
1975	13.400	13.300	13.100	9.800	56.100	40.300	39.600	27.700	7.820	6.860	18.700	18.700	700726
1976	18.400	15.000	7.150	39.500	51.700	45.800	43.300	22.000	7.520	7.350	9.360	8.510	726720
1977	7.550	5.130	4.050	1.700	1.590	2.390	3.970	5.770	3.940	3.630	12.300	11.900	168117
1978	12.100	12.900	8.880	4.560	1.190	.763	.605	1.360	3.230	4.900	8.440	6.140	169466
1979	8.150	9.920	24.300	30.600	53.300	50.300	39.700	5.090	6.310	7.530	10.800	11.400	678381
1980	11.300	10.600	12.400	6.040	1.500	5.130	5.130	4.550	4.360	4.310	8.050	7.620	213055
1981	7.090	7.410	2.730	1.780	.651	.688	.662	.777	2.680	5.570	8.490	7.930	121334
1982	9.010	6.650	2.350	2.220	.811	.697	.659	.736	.879	1.240	7.670	11.200	115462
1983	10.200	9.020	15.300	7.270	36.600	30.200	15.100	18.300	3.700	6.220	13.200	11.800	466800
1984	12.400	10.300	5.480	1.190	1.020	10.800	17.600	3.960	4.280	7.840	10.100	12.700	257541
1985	13.500	17.600	17.500	18.000	41.700	27.100	4.670	4.500	6.850	5.430	17.500	15.500	497932
1986	15.600	14.800	16.300	26.500	33.300	15.500	3.170	5.620	5.490	5.880	13.700	14.200	446366

1987	12.200	9.190	3.600	11.400	6.560	8.710	8.310	7.690	7.690	8.430	9.860	8.980	269222
1988	8.280	4.810	1.830	19.900	42.300	43.900	13.300	8.440	4.580	3.190	5.320	5.530	425041
1989	5.080	7.280	6.370	2.690	1.220	1.180	1.270	3.760	2.870	1.800	2.720	4.890	107458
1990	5.650	10.700	16.000	23.300	9.500	16.600	16.100	11.000	4.210	5.280	6.670	7.130	346763
1991	7.000	6.800	4.610	5.800	2.230	1.700	1.530	2.070	3.410	5.980	8.330	9.870	155485
1992	10.700	15.500	27.400	11.100	3.070	1.770	2.230	4.600	4.680	4.510	4.400	5.120	250087
1993	8.770	5.280	3.400	1.900	.968	.924	1.120	1.580	13.000	15.400	14.400	18.000	222993
1994	17.000	11.900	12.700	3.020	1.950	1.960	25.000	30.600	18.500	9.370	8.570	8.460	393308
1995	7.220	4.700	12.600	106.000	247.000	35.000	40.200	19.500	14.200	13.900	16.000	21.900	1425559
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
MIN	.616	.566	.917	1.190	.651	.688	.605	.352	.233	.235	.367	.550	60069
MAX	18.400	17.600	27.400	185.000	323.000	129.000	96.500	72.200	29.900	41.400	42.600	21.900	1818211
MEAN	5.449	5.017	6.065	34.612	47.851	22.560	17.601	8.894	6.027	6.389	7.789	6.322	461716

C-Files: Pseudo-Natural Flow Arrays for Key Locations

Monthly pseudo-natural flows for the six key base stations, for two additional locations (Spirit Creek near Buchanan and Fishing Lake) and for specific reaches of the Whitesand and Assiniboine Rivers, were obtained from previous studies or were estimated using the procedures documented in Table II.3. These pseudo-natural flow arrays have in some cases been extended beyond the period of the hydrometric record, and are by convention termed "C-Files". The 11 C-Files in Table II.3 were subsequently used to estimate missing monthly pseudo-natural flows for all 23 ASAs in the Upper Assiniboine River Basin.

Table II.3 - Details on Pseudo-Natural Flow Arrays for Key Locations

ASIN C1 Yorkton Creek near Ebenezer (05MB001)

Array provided by Sask Water based on detailed assessment of basin. Mean monthly recorded values of the 05MB001 flows record were adjusted for minor uses, City of Yorkton effluent effects, and the influence of the Yorkton South Complex (YSC) to estimate natural mean monthly flows for 1941-1997 as follows:

Natural Flow = Recorded flow + minor uses - Yorkton Effluent Releases - Net YSC Spill

A number of minor uses within the effective drainage area and below the YSC were added to the first month of runoff. These uses represent stored runoff water. For each year in history, the allocated annual volume (uses + losses) were summed and applied to the first month of runoff. Annual volumes range from 21 dam^3 in 1941 to 65 dam^3 in 1997. Two instream irrigation uses (total allocation 156 dam^3) were treated as follows. Drainage area of the uses is approx. 2.2% of total EDA. 2.2% of recorded flow from May to Sept. of each year was added to the recorded value, until a maximum of 156 dam^3 was added in any one year.

Construction of the YSC has increased spill volumes and hence recorded flows. The difference in the enhanced spill volumes (due to the manmade works) and the natural spill volumes was subtracted from the recorded flows in the years 1983-1997.

The City of Yorkton operates a flow through effluent treatment system with releases to Yorkton Creek, and has for as long as anyone can remember (pers. comm., J. Cheshuk). Release volumes are roughly equal to the water consumption volumes (treatment plant manager). There is evidence of water quality effects at low flows and also of flow appearing at irrational times inconsistent with the nature of the watershed (pers. comm., Environment Canada). It is suspected that effluent releases can contribute significantly to flows at certain periods,. There have been no measurements, records, or studies investigating how much effluent may make it to the station and when. As such, assumptions with no basis in fact (other than those noted above) had to be made, and were applied as follows.

- Releases are continuous
- Recorded water consumption volumes = effluent release volume
- Release volume at the station = 50% of recorded flow to a limit of 50% of total effluent released for the month. (i.e. - half the effluent makes it to the station, but effluent flows never are more than half of the recorded flow).

ASIN C2 Whitesand River near Canora (05MB003)

Recorded flows assumed natural. Missing values estimated by multiplying pseudo-natural flow values for Kamsack (ASIN C4) by 0.386 (ratio of ASIN A2 to ASIN C4 Mar-Oct mean flow for common period 1943-95). Estimated winter flows subjectively adjusted to provide appropriate recession.

Table II.3 - Details on Pseudo-Natural Flow Arrays for Key Locations - continued

ASIN C3 Assiniboine River at Sturgis (05MC001)

Recorded flows assumed natural. Missing values estimated by multiplying pseudo-natural flow values for Kamsack (ASIN C4) by 0.324 (ratio of ASIN A3 to ASIN C4 Mar-Oct mean flow for common period 1944-95). Estimated winter flows subjectively adjusted to provide appropriate recession.

ASIN C4 Assiniboine River at Kamsack (05MD004)

Array obtained from Environment Canada Transboundary Waters Unit (TWU). Data for 1912-77 based on 1980 PPWB Assiniboine River Basin Natural Flow Study conducted by PFRA. Data for 1978-95 based on updates by TWU.

ASIN C5 Shell River near Inglis (05MD005)

Array obtained from Environment Canada Transboundary Waters Unit (TWU). Data for 1912-77 based on 1980 PPWB Assiniboine River Basin Natural Flow Study conducted by PFRA. Data for 1978-95 based on updates by TWU. Recorded flow assumed to be natural.

ASIN C6 Assiniboine River near Russell (05ME001)

Array obtained from Environment Canada Transboundary Waters Unit (TWU). Data for 1912-77 based on 1980 PPWB Assiniboine River Basin Natural Flow Study conducted by PFRA. Data for 1978-95 based on updates by TWU.

ASIN C7 Spirit Creek near Buchanan (05MB007)

Recorded flows assumed natural. Missing values estimated by multiplying pseudo-natural flow values for Kamsack (ASIN C4) by 0.033 (ratio of ASIN A7 to ASIN C4 Mar-Oct mean flow for common period 1965-92). Estimated winter flows subjectively adjusted to provide appropriate recession.

ASIN C8 Fishing Lake Inflow

Net local inflow derived by Sask Water in a July 1997 study of Fishing Lake outlet.

ASIN C9 Incremental Flow for Whitesand River above Canora

05MB003(ASIN C2) - 05MB001(ASIN C1)

Table II.3 - Details on Pseudo-Natural Flow Arrays for Key Locations - continued

ASIN C10 Incremental Flow for Assiniboine River above Kamsack

05MD004(ASIN C4) - 05MC001(ASIN C3) - 05MB003(ASIN C2)

ASIN C11 Incremental Flow for Assiniboine River between Kamsack and Russell

05ME001(ASIN C6) - 05MD005(ASIN C5) - 05MD004(ASIN C4)

D-Files: Pseudo-Natural Flow Arrays for ASAs

Table II.4 details the procedure used to calculate monthly pseudo-natural flows, based on the A- and C-Files, for all 23 ASA's in the Upper Assiniboine River Basin. Tables D-1 to D-24 provide the flow arrays which were subsequently used for water supply modelling purposes.

Table II.4 - D-Files: Pseudo-Natural Flow Calculation Procedure for ASAs

NAME	DESCRIPTION	COMPUTATION PROCEDURE
ASIN D1	Outlet of ASA1 (05MC001)	Same as ASIN C3
ASIN D2	Outlet of ASA2 (05MD004)	Same as ASIN C4
ASIN D3	Outlet of ASA3 (05MB013)	Same as ASIN C8
ASIN D4	Outlet of ASA4 (05MB004)	Missing values of ASIN A9 estimated as ASIN C9 x 0.135 (ratio [1.623/11.992] of Mar-Oct mean flow of ASIN C9 and ASIN A9 for period 1957-73)
ASIN D5	Outlet of ASA5 (05MB006)	Missing values of ASIN A11 estimated as ASIN C10 x 0.160 (ratio [3.501/21.859] of Mar-Oct mean flow of ASIN C10 and ASIN A11 for period 1964-92)
ASIN D6	Outlet of ASA6 (05MB007)	Same as ASIN C7
ASIN D7	Outlet of ASA7 (05MD007)	Missing values of ASIN A21 estimated as ASIN C5 x 0.735 (ratio [69,761/94,970] of Jan-Dec mean flow of ASIN C5 and ASIN A21 for period 1963-76). Note: ratio [17.156/23.017] of Mar-Oct mean flow for period 1963-93 was comparable at 0.745
ASIN D8	Outlet of ASA8 (05MB010)	ASIN C7 x 3.905 (effective drainage area ratio [404.6/103.6])
ASIN D9	Outlet of ASA9 (05MD006)	Missing values of ASIN A20 estimated as ASIN C11 x 0.121 (ratio [2.565/21.137] of Mar-Oct mean flow of ASIN C11 and ASIN A20 for period 1957-73)
ASIN D10	Outlet of ASA10 (05MB009)	ASIN C9 x 0.343 (effective drainage area ratio [546.0/{2002.3-410.0}=546.0/1592.3] of ASIN C9 and 05MB009)
ASIN D11	Outlet of ASA11 (05MB003)	Same as ASIN C2
ASIN D12	Assiniboine River at Kamsack Weir	ASIN C4 - (ASIN C10 x effective drainage area ratio [{2340.3 -2002.3}/{4323.7-2002.3-1143.0}=338.0/1178.4] of 0.287 + ASIN C2)
ASIN D13	Outlet of ASA13 (05MD009)	ASIN C11 x effective drainage area ratio [{7095.3-1126.4-4323.7}/{7664.3-1126.4-4323.7}=1645.2/2214.2] of 0.743 + ASIN C5 + ASIN C4
ASIN D14	Outlet of ASA14 (05MD005)	Same as ASIN C5
ASIN D15	Outlet of ASA15 (Whitesand River above confluence with Yorkton Creek)	ASIN C9 x effective drainage area ratio [{270.1+275.9+138.9}/{2002.3-410.0}=684.9/1592.3] of 0.430

Table II.4 - D-Files: Pseudo-Natural Flow Calculation Procedure for ASAs - continued

ASIN D16	Outlet of ASA16 (05MD010)	Missing values of ASIN A22 estimated as ASIN C11 x 0.066 (ratio [2.427/36.848] of Mar-Oct mean flow of ASIN C11 and ASIN A22 for period 1971-95)
ASIN D17	Outlet of ASA17 (Mouth of Cussed Creek)	ASIN C9 x effective drainage area ratio [{464.2+95.3}/{2002.3-410.0}=559.5/1592.3] of 0.351
ASIN D18	Outlet of ASA18 (05MB001)	Same as ASIN C1
ASIN D19	Outlet of ASA19 (05ME005)	Missing values of ASIN A23 estimated as ASIN C11 x 0.031 (ratio [0.960/31.141] of Mar-Oct mean flow of ASIN C11 and ASIN A23 for period 1959-95)
ASIN D20	Outlet of ASA20 (05MB005)	Missing values of ASIN A10 estimated as ASIN C9 x 0.057 (ratio [1.088/19.153] of Mar-Oct mean flow of ASIN C9 and ASIN A10 for period 1964-92)
ASIN D22	Outlet of ASA22 (05ME007)	Missing values of ASIN A24 estimated as ASIN C11 x 0.044 (ratio [1.674/37.657] of Mar-Oct mean flow of ASIN C11 and ASIN A24 for period 1975-95)
ASIN D23	Outlet of ASA23 (Assiniboine River above junction with Qu'Appelle River)	Effective drainage area ratio [755.0/451.4] of 1.673 x (ASIN D24-ASIN D22 - ASIN D19 - ASIN D13) + ASIN C6
ASIN D24	Outlet of ASA24 (05ME001)	Same as ASIN C6

Table D-1

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA1 ASIN D1
ASSINIBOINE RIVER AT STURGIS (05MC001)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.026	4.060	.687	.431	.000	.000	.003	.000	.000	.000	13558
1942	.000	.000	.159	10.277	1.183	2.728	.855	1.102	.872	.625	.130	.032	46902
1943	.032	.019	.042	12.876	2.919	1.837	1.280	.369	.214	.188	.136	.058	52181
1944	.013	.016	.023	.806	.553	.181	.083	.028	.019	.020	.130	.042	5026
1945	.010	.019	.213	2.430	1.650	.973	.706	.107	.116	.143	.038	.039	16947
1946	.019	.019	1.050	4.050	1.260	.766	.362	.043	.232	.228	.411	.065	22303
1947	.023	.026	.032	3.130	4.720	1.610	2.270	.410	.474	.527	.318	.133	36137
1948	.087	.065	.068	8.020	20.900	1.770	.523	.267	.048	.073	.230	.091	85208
1949	.045	.010	.016	1.020	1.330	3.960	.806	.199	.031	.044	.004	.000	19558
1950	.000	.000	.071	3.620	3.440	1.110	.482	2.100	.186	.166	.340	.104	30666
1951	.065	.049	.042	6.620	14.000	3.430	1.670	.955	3.550	6.680	1.066	.117	101153
1952	.042	.036	.119	18.900	6.230	1.850	.446	.232	.085	.187	.172	.055	74122
1953	.029	.036	.049	4.300	9.460	16.300	26.600	14.800	7.010	1.960	1.680	.211	218254
1954	.113	.084	.133	6.260	29.100	44.600	5.640	2.180	5.060	3.700	1.750	.577	260685
1955	.243	.211	.188	26.800	36.000	4.600	1.130	.338	.216	.259	.415	.314	186578
1956	.185	.152	.162	4.380	32.300	5.980	1.590	.600	.632	.597	.619	.318	126235
1957	.146	.126	.133	12.800	9.230	.916	.364	.199	.261	.221	.081	.113	64615
1958	.058	.104	.153	1.890	.631	.299	.104	.000	.000	.000	.000	.000	8459
1959	.000	.000	.149	.888	.426	.029	.109	.030	.139	.516	.178	.071	6683
1960	.000	.000	.000	17.200	6.870	5.810	1.790	.044	.005	.000	.000	.000	82968
1961	.000	.000	.037	.305	.481	.029	.000	.000	.000	.000	.000	.000	2253
1962	.000	.000	.000	5.100	1.790	.185	.000	.000	.000	.000	.000	.000	18493
1963	.000	.000	.209	3.450	.444	.367	.133	.000	.000	.000	.000	.000	11999
1964	.000	.000	.000	1.733	1.814	.282	.107	.120	.256	.237	.237	.094	12854
1965	.000	.000	.000	9.250	5.730	19.700	4.240	.594	.352	.380	.291	.211	106563
1966	.188	.126	.668	18.600	9.900	3.880	2.400	2.170	.538	.323	.275	.240	103237
1967	.168	.133	.233	3.990	16.400	2.530	.156	.000	.000	.000	.000	.000	62639
1968	.000	.000	.201	3.220	.232	.161	.209	.332	.085	.216	.058	.052	12461
1969	.045	.029	.082	8.020	1.340	.254	.114	.010	.002	.150	.123	.049	26635
1970	.029	.029	.027	7.250	12.400	2.840	1.350	.671	.122	.232	.645	.256	68294
1971	.130	.107	.294	22.500	4.190	2.390	.685	1.020	.043	.160	.305	.311	83862
1972	.201	.110	.202	26.000	28.100	1.510	.434	.140	.040	.490	.094	.052	151260
1973	.036	.032	.345	4.290	3.860	5.360	5.920	.530	.058	.197	.136	.188	55259
1974	.120	.120	.190	15.700	29.800	10.700	.922	.125	.786	.948	.564	.499	159545
1975	.269	.240	.327	15.900	22.000	5.660	1.710	.180	.285	.494	.567	.275	126316
1976	.146	.136	.172	30.000	4.680	8.590	6.320	.656	.411	.106	.246	.220	135013
1977	.139	.133	.146	4.460	1.180	.182	.023	.016	.042	.047	.159	.143	17412
1978	.094	.069	.056	6.930	2.600	.170	1.510	.141	.107	.139	.233	.194	32131
1979	.144	.111	.154	16.000	32.500	6.590	.533	.090	.015	.063	.141	.159	149336
1980	.154	.129	.132	6.820	.668	.115	.062	.062	.063	.163	.168	.110	22516
1981	.067	.066	.837	3.530	.883	.241	.139	.267	.065	.834	.535	.207	20151
1982	.077	.059	.106	5.300	1.690	.457	.141	.078	.035	.166	.119	.073	21707
1983	.085	.099	.050	7.240	5.870	2.390	1.490	.566	.046	.086	.197	.208	48208
1984	.131	.128	.829	6.610	3.020	4.700	.327	.062	.003	.179	.264	.223	43107
1985	.122	.113	.107	18.800	5.180	.512	.049	.020	.007	.126	.183	.130	66180
1986	.129	.148	.594	13.300	2.250	.458	.559	.027	.009	.116	.139	.152	46653
1987	.138	.139	.271	10.400	1.090	.380	.170	.143	.020	.119	.238	.275	34855
1988	.146	.152	.210	15.100	8.710	.861	.018	.004	.000	.003	.000	.000	66101
1989	.000	.000	.021	1.250	.290	.412	.370	.058	.224	.312	.157	.099	8376
1990	.095	.075	.079	7.050	2.420	.427	.107	.014	.002	.001	.000	.000	26842
1991	.000	.000	.028	1.250	.565	.136	.893	.004	.000	.005	.000	.000	7597
1992	.000	.000	.124	4.520	1.110	.063	.010	.008	.013	.013	.000	.000	15301
1993	.000	.000	.264	.922	.290	.136	5.430	12.000	6.290	1.900	.756	.425	75401
1994	.305	.191	1.270	6.430	2.470	2.000	1.340	.266	.225	.151	.278	.269	39877
1995	.212	.216	.371	31.500	23.100	6.210	7.040	9.430	2.220	1.430	2.418	1.008	224364
MIN	.000	.000	.000	.305	.232	.029	.000	.000	.000	.000	.000	.000	2253
MAX	.305	.240	1.270	31.500	36.000	44.600	26.600	14.800	7.010	6.680	2.418	1.008	260685
MEAN	.081	.070	.208	8.964	7.672	3.456	1.668	.978	.573	.471	.313	.154	64746

Table D-2

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA2
ASSINIBOINE RIVER AT KAMSACK (05MD004)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.070	.070	.080	12.530	2.120	1.330	.000	.000	.010	.000	.010	.100	42494
1942	.030	.020	.490	31.720	3.650	8.420	2.640	3.400	2.690	1.930	.400	.100	144884
1943	.100	.060	.130	39.740	9.010	5.670	3.950	1.140	.660	.580	.420	.180	161064
1944	.040	.050	.070	2.760	1.420	.990	.500	.140	.160	.180	.400	.130	17939
1945	.030	.060	.430	6.640	4.070	2.380	1.320	.310	.320	.590	.410	.120	43818
1946	.060	.060	.850	13.980	3.180	1.190	.640	.300	.260	.400	1.270	.200	58511
1947	.070	.080	.100	22.850	18.810	5.220	4.860	.990	.860	1.150	.980	.410	148403
1948	.270	.200	.210	22.450	74.470	5.910	2.480	1.030	.290	.440	.710	.280	288678
1949	.140	.030	.050	22.140	1.780	5.310	1.420	.510	.170	.200	.740	.210	85126
1950	.100	.100	.220	14.690	9.810	2.470	1.020	2.280	.580	.350	1.050	.320	86711
1951	.200	.150	.130	21.140	32.320	6.630	3.100	1.260	3.260	7.890	3.290	.360	210545
1952	.130	.110	.130	37.850	12.350	3.550	1.270	.350	.230	.270	.530	.170	148846
1953	.090	.110	.150	17.330	16.610	21.310	62.890	31.180	12.720	5.240	4.460	.650	457815
1954	.350	.260	.410	32.970	64.720	118.250	38.850	9.490	12.200	13.570	7.830	1.780	790478
1955	.750	.650	.580	95.430	135.020	33.580	12.800	4.850	2.360	2.310	1.280	.970	766660
1956	.570	.470	.500	46.160	128.100	30.950	10.990	3.180	2.340	1.800	1.910	.980	603431
1957	.450	.390	.420	42.330	46.140	5.850	1.860	1.130	1.140	.170	.250	.350	264742
1958	.180	.320	.340	8.850	2.610	.740	.140	.060	.060	.110	.390	.080	36226
1959	.070	.050	1.150	5.890	1.650	.500	.610	.190	.240	.640	.550	.220	30865
1960	.190	.220	.150	54.800	19.760	9.560	3.750	.200	.070	.050	.190	.240	233239
1961	.180	.090	.230	.870	.750	.390	.020	.010	.010	.010	.010	.010	6776
1962	.010	.010	.020	20.330	7.210	1.240	.270	.020	.080	.060	.090	.010	76730
1963	.010	.010	.970	6.640	1.540	1.170	.560	.100	.010	.060	.040	.040	29182
1964	.040	.040	.040	5.350	5.600	.870	.330	.370	.790	.730	.730	.290	39982
1965	.230	.200	.180	26.780	9.620	19.940	5.780	1.400	1.460	3.430	1.620	.650	186589
1966	.580	.390	.820	56.040	24.280	9.260	6.400	4.940	1.810	.620	.850	.740	279893
1967	.520	.410	.280	12.540	42.920	6.030	.810	.380	.220	.570	.180	.200	172511
1968	.160	.190	1.760	8.790	1.380	.890	.500	.510	.510	.170	.180	.160	39783
1969	.140	.090	.150	27.580	5.110	1.380	.760	.710	.260	.710	.380	.150	97645
1970	.090	.090	.090	21.970	28.680	6.380	3.800	1.010	.170	.990	1.990	.790	174249
1971	.400	.330	.300	69.580	18.290	6.470	3.230	2.020	.330	.670	.940	.960	270502
1972	.620	.340	.770	65.590	60.510	3.980	.930	.410	.190	.180	.290	.160	352714
1973	.110	.100	.720	5.340	5.590	8.460	7.540	1.170	.370	.290	.420	.580	80914
1974	.370	.370	.360	48.850	70.180	30.700	2.350	1.220	1.740	1.940	1.740	1.540	424917
1975	.830	.740	.600	46.460	91.200	20.170	6.910	1.600	1.480	1.480	1.750	.850	460001
1976	.450	.420	.890	101.940	26.870	21.890	20.390	3.380	.730	.570	.760	.680	468453
1977	.430	.410	.510	10.480	4.390	.950	.350	.310	.190	.490	.490	.440	50916
1978	.291	.212	.294	16.186	7.159	1.081	1.366	.306	.116	.240	.719	.598	74898
1979	.444	.344	.259	42.350	94.344	14.313	2.151	.707	.616	.393	.435	.490	415021
1980	.474	.397	.379	29.375	5.376	.775	.601	.138	.181	.341	.519	.340	101445
1981	.208	.204	1.811	5.213	1.881	1.601	1.358	.786	.201	1.421	1.652	.640	44667
1982	.238	.181	.365	9.989	4.419	1.624	5.211	.685	.106	.280	.368	.225	62363
1983	.263	.307	.316	26.444	35.428	8.737	11.832	3.062	.395	.222	.607	.641	233174
1984	.404	.395	4.556	16.000	7.532	8.643	2.432	.466	.091	.223	.814	.687	110868
1985	.375	.349	.365	79.278	28.271	6.772	1.763	.629	.369	.615	.565	.402	313141
1986	.398	.457	2.108	61.567	12.393	4.004	2.443	.998	.144	.263	.428	.468	223628
1987	.425	.429	1.782	29.669	4.711	1.898	2.107	.705	.309	.409	.735	.850	114998
1988	2.302	1.705	1.872	46.355	26.896	4.289	.719	.320	.201	.154	.236	.264	223794
1989	.192	.188	.220	3.248	1.150	1.122	.921	.277	.241	.112	.486	.306	22178
1990	.294	.232	.272	42.307	11.140	2.077	.620	.360	.255	.120	.092	.181	151288
1991	.139	.171	.208	5.670	1.974	.692	1.420	.410	.126	.080	.227	.233	29775
1992	.171	.290	.319	19.561	7.507	1.138	.921	.355	.288	.418	.376	.298	82854
1993	.249	.233	1.028	2.925	1.536	.882	15.465	8.818	12.912	4.440	2.334	1.312	137929
1994	.941	.590	5.192	17.191	6.769	7.652	11.666	1.301	.718	.839	.859	.831	143668
1995	.654	.668	1.432	144.620	119.140	22.117	11.135	15.943	8.763	5.772	7.464	3.112	896871
MIN	.010	.010	.020	.870	.750	.390	.000	.000	.010	.000	.010	.010	6776
MAX	2.302	1.705	5.192	144.620	135.020	118.250	62.890	31.180	12.912	13.570	7.830	3.112	896871
MEAN	.319	.274	.692	30.642	24.897	9.080	5.275	2.142	1.400	1.221	1.063	.509	203905

Table D-3

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA3 ASIN D3
FISHING LAKE NEAR WADENA (05MB013)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.277	.020	.000	.000	.000	.000	.000	.000	.000	772
1942	.000	.000	.314	1.304	.112	.016	.000	.000	.000	.000	.000	.000	4562
1943	.000	.000	.000	1.506	.677	.000	.000	.000	.000	.000	.000	.000	5717
1944	.000	.000	.000	.140	.115	.000	.000	.000	.000	.000	.000	.000	671
1945	.000	.000	.000	1.031	.016	.000	.000	.000	.000	.000	.000	.000	2715
1946	.000	.000	.000	1.055	.014	.008	.200	.000	.008	.045	.000	.000	3470
1947	.000	.000	.012	1.762	.197	.027	.000	.000	.000	.000	.000	.000	5197
1948	.000	.000	.000	1.940	.971	.000	.000	.000	.000	.000	.000	.000	7629
1949	.000	.000	.000	.505	.008	.000	.000	.000	.000	.000	.000	.000	1330
1950	.000	.000	.000	.878	.003	.005	.000	.000	.000	.000	.000	.000	2297
1951	.000	.000	.000	.944	.208	.017	.392	.048	.014	.000	.000	.000	4263
1952	.000	.000	.174	.722	.062	.009	.000	.000	.000	.000	.000	.000	2527
1953	.000	.000	.000	1.910	.956	.000	.000	.000	.000	.000	.000	.000	7511
1954	.000	.000	.000	2.426	2.245	.071	.002	.000	.000	.000	.000	.000	12491
1955	.000	.000	.000	2.259	2.091	.066	.001	.000	.000	.000	.000	.000	11630
1956	.000	.000	.000	1.927	1.783	.056	.001	.000	.000	.000	.000	.000	9918
1957	.000	.000	.000	.993	.219	.018	.413	.051	.002	.000	.000	.000	4455
1958	.000	.000	.000	.054	.012	.069	.250	.000	.000	.000	.000	.000	1021
1959	.000	.000	.000	.310	.022	.000	.000	.000	.000	.000	.000	.000	862
1960	.000	.000	.000	2.618	.274	.000	.000	.000	.000	.000	.000	.000	7520
1961	.000	.000	.000	.031	.025	.000	.000	.000	.000	.000	.000	.000	147
1962	.000	.000	.000	1.300	.000	.000	.000	.000	.000	.000	.000	.000	3370
1963	.000	.000	.160	.269	.012	.000	.000	.000	.000	.000	.000	.000	1158
1964	.000	.000	.000	.133	.109	.000	.000	.000	.000	.000	.000	.000	637
1965	.000	.000	.000	.928	.045	.000	.000	.000	.000	.000	.000	.000	2526
1966	.000	.000	.000	2.915	.306	.000	.000	.000	.000	.000	.000	.000	8375
1967	.000	.000	.000	1.571	.707	.000	.000	.000	.000	.000	.000	.000	5966
1968	.000	.000	.337	.121	.000	.000	.000	.000	.000	.000	.000	.000	1216
1969	.000	.000	.000	2.050	.018	.000	.000	.000	.000	.000	.000	.000	5362
1970	.000	.000	.000	2.173	.453	.000	.000	.000	.000	.000	.000	.000	6846
1971	.000	.000	.000	2.287	.102	.000	.000	.000	.000	.000	.000	.000	6201
1972	.000	.000	.000	4.858	1.277	.118	.000	.000	.000	.000	.000	.000	16318
1973	.000	.000	.000	.053	.012	.068	.245	.000	.000	.000	.000	.000	1002
1974	.000	.000	.000	3.672	1.837	.000	.000	.000	.000	.000	.000	.000	14439
1975	.000	.000	.000	2.947	1.654	.472	.030	.000	.000	.000	.000	.000	13372
1976	.000	.000	.000	4.345	.358	.260	.071	.000	.000	.000	.000	.000	13085
1977	.000	.000	.000	.334	.024	.000	.000	.000	.000	.000	.000	.000	930
1978	.000	.000	.000	1.108	.015	.009	.210	.000	.009	.047	.000	.000	3647
1979	.000	.000	.000	4.206	3.892	.123	.003	.000	.000	.000	.000	.000	21653
1980	.000	.000	.000	2.321	.018	.000	.000	.000	.000	.000	.000	.000	6064
1981	.000	.000	.186	.402	.009	.000	.006	.000	.000	.000	.000	.000	1580
1982	.000	.000	.000	.600	.024	.006	.000	.000	.000	.000	.000	.000	1635
1983	.000	.000	.000	1.897	.418	.034	.789	.096	.003	.000	.000	.000	8503
1984	.000	.000	.492	1.765	.268	.075	.040	.000	.000	.000	.000	.000	6912
1985	.000	.000	.028	3.968	.444	.061	.000	.000	.000	.000	.000	.000	11707
1986	.000	.000	.355	1.475	.127	.018	.000	.000	.000	.000	.000	.000	5161
1987	.000	.000	.000	1.631	.006	.009	.000	.000	.000	.000	.000	.000	4267
1988	.000	.000	.000	2.387	.106	.000	.000	.000	.000	.000	.000	.000	6471
1989	.000	.000	.000	.056	.013	.072	.259	.000	.000	.000	.000	.000	1060
1990	.000	.000	.000	1.800	.007	.010	.000	.000	.000	.000	.000	.000	4710
1991	.000	.000	.000	.296	.021	.000	.000	.000	.000	.000	.000	.000	823
1992	.000	.000	.000	1.328	.000	.000	.000	.000	.000	.000	.000	.000	3442
1993	.000	.000	.000	1.677	.006	.009	.000	.000	.000	.000	.000	.000	4386
1994	.000	.000	.316	1.316	.113	.016	.000	.000	.000	.000	.000	.000	4602
1995	.000	.000	.000	5.586	5.169	.163	.004	.000	.000	.000	.000	.000	28757
MIN	.000	.000	.000	.031	.000	.000	.000	.000	.000	.000	.000	.000	147
MAX	.000	.000	.492	5.586	5.169	.472	.789	.096	.014	.047	.000	.000	28757
MEAN	.000	.000	.043	1.607	.502	.034	.053	.004	.001	.002	.000	.000	5871

Table D-4

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA4 ASIN D4
WHITESAND RIVER NEAR SHEHO (05MB004)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.529	.108	.069	.000	.000	.000	.000	.000	.000	1839
1942	.000	.000	.026	1.237	.156	.436	.138	.145	.140	.101	.021	.000	6267
1943	.000	.000	.000	1.283	.258	.186	.079	.058	.034	.030	.022	.000	5092
1944	.000	.000	.000	.058	.043	.034	.005	.000	.000	.000	.000	.000	366
1945	.000	.000	.000	.109	.060	.043	.022	.000	.004	.010	.000	.000	654
1946	.000	.000	.019	.344	.056	.017	.007	.000	.007	.023	.000	.000	1238
1947	.000	.000	.000	.944	.965	.198	.135	.017	.015	.020	.000	.000	6044
1948	.000	.000	.000	2.905	2.520	.116	.071	.016	.001	.001	.000	.000	14818
1949	.000	.000	.000	.000	.019	.000	.004	.009	.009	.000	.000	.000	110
1950	.000	.000	.011	.683	.278	.043	.023	.019	.000	.000	.000	.000	2771
1951	.000	.000	.000	.714	1.118	.129	.047	.006	.022	.049	.036	.000	5607
1952	.000	.000	.001	1.135	.149	.030	.003	.000	.000	.000	.000	.000	3430
1953	.000	.000	.008	.698	.378	.753	2.338	1.107	.339	.155	.193	.034	15908
1954	.018	.014	.021	2.273	1.582	5.608	1.538	.413	.537	.676	.300	.093	34259
1955	.039	.034	.030	5.106	7.900	1.820	.956	.381	.100	.111	.067	.050	43823
1956	.030	.024	.026	3.621	6.010	1.431	.617	.143	.068	.074	.099	.000	32069
1957	.000	.000	.000	2.000	.859	.072	.000	.000	.000	.000	.000	.000	7671
1958	.000	.000	.000	.055	.016	.000	.000	.000	.000	.000	.000	.000	185
1959	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1960	.000	.000	.000	1.450	.340	1.100	.273	.000	.000	.000	.000	.000	8251
1961	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1962	.000	.000	.000	.032	.029	.000	.000	.000	.000	.000	.000	.000	161
1963	.000	.000	.011	.062	.007	.000	.000	.000	.000	.000	.000	.000	209
1964	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.038	.000	99
1965	.000	.000	.000	.082	.004	.297	.120	.005	.000	.000	.000	.000	1328
1966	.000	.000	.000	2.390	.918	.292	.169	.249	.107	.017	.000	.000	10853
1967	.000	.000	.000	.063	2.270	.495	.011	.000	.000	.000	.009	.000	7580
1968	.000	.000	.131	.092	.036	.004	.000	.000	.000	.000	.000	.000	696
1969	.000	.000	.000	.376	.077	.002	.000	.000	.000	.000	.020	.000	1237
1970	.000	.000	.000	1.290	1.090	.182	.029	.000	.000	.000	.036	.000	6906
1971	.000	.000	.000	2.830	.611	.125	.072	.018	.000	.000	.000	.000	9537
1972	.000	.000	.000	3.040	2.030	.154	.011	.000	.000	.000	.000	.000	13745
1973	.000	.000	.000	.003	.230	1.090	.278	.001	.000	.000	.000	.000	4196
1974	.000	.000	.005	2.230	2.480	1.021	.049	.032	.036	.025	.010	.000	15486
1975	.000	.000	.015	2.495	4.861	.695	.239	.062	.068	.047	.091	.044	22792
1976	.023	.022	.029	5.580	1.284	1.122	1.054	.197	.055	.021	.013	.000	24588
1977	.000	.000	.009	.149	.167	.001	.000	.000	.000	.000	.000	.000	860
1978	.000	.000	.000	.296	.050	.000	.084	.005	.000	.000	.000	.000	1139
1979	.000	.000	.001	2.340	3.518	.490	.039	.006	.036	.020	.023	.000	17083
1980	.000	.000	.000	.882	.230	.023	.000	.000	.000	.002	.000	.000	2966
1981	.000	.000	.027	.020	.013	.087	.040	.002	.000	.060	.086	.033	970
1982	.012	.009	.004	.419	.142	.053	.194	.010	.000	.000	.000	.000	2215
1983	.000	.000	.009	1.342	1.319	.444	.733	.136	.000	.000	.000	.000	10515
1984	.000	.000	.085	.386	.228	.115	.032	.000	.000	.015	.000	.000	2262
1985	.000	.000	.008	4.737	1.187	.393	.121	.034	.015	.023	.016	.000	17053
1986	.000	.000	.232	2.739	.730	.262	.177	.044	.000	.000	.000	.000	10949
1987	.000	.000	.000	.740	.196	.033	.080	.000	.000	.000	.000	.000	2742
1988	.000	.056	.057	1.142	1.081	.271	.000	.000	.000	.000	.000	.000	6855
1989	.000	.000	.000	.015	.000	.018	.000	.000	.000	.000	.022	.002	150
1990	.000	.000	.000	2.356	.601	.001	.000	.000	.000	.000	.016	.009	7785
1991	.000	.000	.000	.157	.025	.000	.000	.000	.000	.000	.006	.006	507
1992	.000	.000	.000	.454	.317	.003	.121	.000	.025	.000	.000	.000	2422
1993	.000	.003	.024	.044	.003	.028	.602	.054	.044	.011	.000	.000	2165
1994	.000	.000	.401	.840	.300	.392	.975	.050	.027	.027	.031	.016	8081
1995	.007	.008	.159	9.233	6.035	1.334	.000	.190	.335	.396	.365	.145	47785
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
MAX	.039	.056	.401	9.233	7.900	5.608	2.338	1.107	.537	.676	.365	.145	47785
MEAN	.002	.003	.025	1.345	.998	.391	.209	.062	.037	.035	.028	.008	8260

Table D-5

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA5 CROOKED HILL CREEK NEAR CANORA (05MB006) (m^3/s)

ASIN D5

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.581	.098	.062	.000	.000	.000	.000	.000	.000	1929
1942	.000	.000	.023	1.472	.169	.391	.123	.000	.000	.000	.000	.000	5673
1943	.000	.000	.000	2.298	.618	.365	.327	.000	.000	.000	.000	.000	9434
1944	.000	.000	.000	.133	.086	.086	.061	.000	.000	.000	.000	.000	961
1945	.000	.000	.000	.470	.315	.174	.059	.000	.000	.000	.000	.000	2671
1946	.000	.000	.000	1.149	.239	.048	.000	.000	.000	.000	.000	.000	3743
1947	.000	.000	.000	1.219	.930	.318	.243	.000	.000	.000	.000	.000	7126
1948	.000	.000	.000	.000	4.747	.513	.197	.101	.000	.000	.000	.000	14842
1949	.000	.000	.000	3.160	.000	.000	.000	.000	.000	.000	.000	.000	8191
1950	.000	.000	.000	.454	.672	.165	.056	.000	.000	.000	.000	.000	3554
1951	.000	.000	.000	.901	1.520	.354	.168	.039	.000	.000	.000	.000	7879
1952	.000	.000	.000	1.478	.802	.235	.128	.000	.000	.000	.000	.000	6931
1953	.000	.000	.000	.776	.675	.000	2.558	1.190	.453	.291	.000	.000	15812
1954	.000	.000	.019	1.234	3.491	4.024	2.514	.253	.106	.000	.000	.000	30716
1955	.000	.000	.027	2.917	3.907	1.341	.155	.000	.000	.000	.000	.000	21989
1956	.000	.000	.000	1.910	6.840	.093	.422	.104	.000	.000	.000	.000	24921
1957	.000	.000	.046	1.550	.520	.393	.102	.000	.000	.000	.000	.000	6825
1958	.000	.000	.005	.131	.201	.000	.000	.000	.000	.000	.000	.000	891
1959	.000	.000	.006	.055	.175	.062	.000	.000	.000	.000	.000	.000	788
1960	.000	.000	.000	2.100	.079	.317	.195	.000	.000	.000	.000	.000	6999
1961	.000	.000	.031	.061	.034	.058	.000	.000	.000	.000	.000	.000	483
1962	.000	.000	.000	.308	.035	.148	.043	.000	.000	.000	.000	.000	1391
1963	.000	.000	.044	.133	.169	.119	.065	.000	.000	.000	.000	.000	1398
1964	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1965	.000	.002	.000	.569	.044	.025	.000	.000	.000	.000	.000	.000	1662
1966	.000	.000	.000	2.690	.513	.128	.026	.006	.000	.000	.000	.000	8764
1967	.000	.000	.000	.360	1.500	.037	.000	.000	.000	.000	.000	.000	5047
1968	.000	.000	.005	.384	.000	.000	.000	.000	.000	.000	.000	.000	1009
1969	.000	.000	.000	1.460	.026	.000	.000	.000	.000	.000	.000	.000	3854
1970	.000	.000	.000	.786	.522	.024	.031	.000	.000	.000	.000	.000	3581
1971	.000	.000	.000	4.170	.527	.000	.000	.000	.003	.107	.000	.000	12515
1972	.000	.000	.000	5.860	1.450	.014	.000	.000	.000	.000	.000	.000	19109
1973	.000	.000	.029	.068	.033	.006	.011	.000	.000	.000	.000	.000	387
1974	.000	.000	.000	4.680	3.820	.660	.000	.000	.000	.000	.000	.000	24073
1975	.000	.000	.000	4.210	2.990	.035	.033	.000	.000	.000	.000	.000	19100
1976	.000	.000	.000	9.610	.148	.419	.063	.006	.000	.000	.000	.000	26576
1977	.000	.000	.000	1.120	.025	.000	.000	.000	.000	.000	.000	.000	2970
1978	.000	.000	.001	.906	.049	.000	.000	.000	.000	.000	.000	.000	2482
1979	.000	.000	.000	4.710	4.200	.722	.000	.000	.000	.000	.000	.000	25329
1980	.000	.000	.000	2.680	.057	.007	.008	.000	.000	.000	.000	.000	7139
1981	.000	.000	.099	.004	.000	.000	.000	.000	.000	.000	.000	.000	276
1982	.000	.000	.006	.145	.004	.001	.198	.008	.001	.001	.000	.000	962
1983	.000	.000	.000	3.530	2.140	.066	.066	.110	.003	.000	.000	.000	15532
1984	.000	.000	.618	.636	.064	.085	.001	.000	.000	.000	.000	.000	3698
1985	.000	.000	.000	7.490	.444	.024	.003	.000	.000	.000	.000	.000	20674
1986	.000	.000	.297	4.780	.107	.017	.020	.006	.000	.000	.000	.000	13586
1987	.000	.000	.021	2.760	.021	.000	.383	.033	.001	.002	.000	.000	8389
1988	.000	.000	.003	5.250	.480	.001	.000	.000	.000	.000	.000	.000	14904
1989	.000	.000	.001	.170	.001	.001	.000	.000	.000	.005	.000	.000	462
1990	.000	.000	.000	4.920	.163	.002	.000	.000	.000	.000	.000	.000	13194
1991	.000	.000	.000	.312	.013	.008	.000	.000	.000	.000	.000	.000	864
1992	.000	.000	.000	3.190	.209	.000	.085	.001	.025	.000	.000	.000	9123
1993	.000	.000	.059	.244	.169	.067	.000	.000	.000	.000	.000	.000	1417
1994	.000	.000	.152	.727	.289	.000	.000	.000	.000	.000	.000	.000	3066
1995	.000	.000	.000	5.875	7.094	.481	.434	.592	.572	.000	.000	.000	39706
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
MAX	.000	.002	.618	9.610	7.094	4.024	2.558	1.190	.572	.291	.000	.000	39706
MEAN	.000	.000	.027	1.978	.971	.220	.160	.045	.021	.007	.000	.000	8993

Table D-6

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA6   ASIN D6
SPIRIT CREEK NEAR BUCHANAN (05MB007)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.413	.070	.000	.000	.000	.000	.000	.000	.000	1258
1942	.000	.000	.016	1.047	.120	.278	.087	.000	.000	.000	.000	.000	4032
1943	.000	.000	.000	1.311	.297	.187	.130	.000	.000	.000	.000	.000	5026
1944	.000	.000	.000	.091	.047	.033	.016	.000	.000	.000	.000	.000	490
1945	.000	.000	.014	.219	.134	.079	.044	.000	.000	.000	.000	.000	1287
1946	.000	.000	.028	.461	.105	.039	.000	.000	.000	.000	.000	.000	1652
1947	.000	.000	.000	.754	.621	.172	.000	.000	.000	.000	.000	.000	4063
1948	.000	.000	.000	.741	2.458	.195	.082	.000	.000	.000	.000	.000	9229
1949	.000	.000	.000	.731	.059	.175	.047	.000	.000	.000	.000	.000	2632
1950	.000	.000	.000	.485	.324	.082	.000	.000	.000	.000	.000	.000	2337
1951	.000	.000	.000	.698	1.067	.219	.102	.000	.000	.000	.000	.000	5508
1952	.000	.000	.000	1.249	.408	.117	.000	.000	.000	.000	.000	.000	4633
1953	.000	.000	.000	.572	.548	.703	2.075	1.029	.420	.173	.000	.000	14638
1954	.000	.000	.000	1.088	2.136	3.902	1.282	.313	.000	.000	.000	.000	22927
1955	.000	.000	.019	3.149	4.456	1.108	.422	.160	.078	.000	.000	.000	24781
1956	.000	.000	.000	1.523	4.227	1.021	.363	.105	.000	.000	.000	.000	19169
1957	.000	.000	.000	2.380	5.530	2.050	.000	.000	.000	.000	.000	.000	26294
1958	.000	.000	.110	.388	.086	.000	.000	.000	.000	.000	.000	.000	1531
1959	.000	.000	.168	.310	.054	.000	.000	.000	.000	.000	.000	.000	1398
1960	.000	.000	.045	1.790	.181	.000	.000	.000	.000	.000	.000	.000	5245
1961	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1962	.000	.000	.000	1.180	.117	.041	.000	.000	.000	.000	.000	.000	3478
1963	.000	.000	.051	.028	.000	.000	.000	.000	.000	.000	.000	.000	209
1964	.000	.000	.000	.300	.031	.000	.000	.000	.000	.000	.000	.000	861
1965	.000	.000	.000	.760	.071	.095	.041	.000	.000	.010	.000	.000	2543
1966	.000	.000	.000	2.240	.470	.014	.002	.018	.003	.000	.000	.000	7163
1967	.000	.000	.000	1.100	1.230	.018	.000	.000	.000	.000	.000	.000	6192
1968	.000	.000	.371	.140	.010	.002	.000	.000	.000	.000	.000	.000	1389
1969	.000	.000	.000	.973	.006	.002	.019	.002	.000	.000	.000	.000	2600
1970	.000	.000	.000	.968	.317	.003	.002	.000	.000	.000	.000	.000	3371
1971	.000	.000	.000	2.610	.026	.008	.000	.001	.000	.000	.000	.000	6858
1972	.000	.000	.000	4.110	.434	.001	.000	.000	.000	.000	.000	.000	11818
1973	.000	.000	.075	.119	.026	.170	.026	.000	.000	.000	.000	.000	1089
1974	.000	.000	.000	3.110	2.160	.266	.001	.000	.000	.000	.000	.000	14539
1975	.000	.000	.000	3.040	1.110	.023	.000	.000	.000	.000	.000	.000	10912
1976	.000	.000	.000	4.720	.046	.146	.027	.000	.000	.000	.000	.000	12808
1977	.000	.000	.000	.521	.002	.000	.000	.000	.000	.000	.000	.000	1356
1978	.000	.000	.000	.533	.015	.003	.146	.000	.000	.000	.000	.000	1821
1979	.000	.000	.000	3.770	1.510	.069	.001	.000	.000	.000	.000	.000	13998
1980	.000	.000	.000	1.330	.002	.000	.000	.000	.000	.000	.000	.000	3453
1981	.000	.000	.092	.002	.000	.000	.007	.000	.000	.006	.000	.000	286
1982	.000	.000	.022	.580	.003	.000	.001	.000	.000	.000	.000	.000	1573
1983	.000	.000	.000	1.810	.317	.020	.021	.003	.001	.000	.000	.000	5659
1984	.000	.000	.846	.470	.021	.093	.010	.000	.001	.001	.000	.000	3814
1985	.000	.000	.000	4.560	.126	.001	.000	.000	.000	.000	.000	.000	12160
1986	.000	.000	.717	1.980	.018	.000	.004	.018	.000	.000	.000	.000	7160
1987	.000	.000	.008	1.840	.026	.032	.000	.000	.000	.000	.000	.000	4943
1988	.000	.000	.000	3.660	.076	.000	.000	.000	.000	.000	.000	.000	9690
1989	.000	.000	.000	.001	.001	.000	.000	.000	.000	.000	.000	.000	5
1990	.000	.000	.123	3.710	.063	.001	.000	.000	.000	.000	.000	.000	10117
1991	.000	.000	.000	.370	.005	.001	.000	.000	.000	.000	.000	.000	975
1992	.000	.000	.000	2.600	.058	.000	.000	.000	.000	.000	.000	.000	6895
1993	.000	.000	.034	.097	.051	.029	.000	.000	.000	.000	.000	.000	554
1994	.000	.000	.171	.567	.223	.253	.185	.000	.000	.000	.000	.000	3676
1995	.000	.000	.047	4.772	3.932	.730	.367	.126	.000	.000	.000	.000	26239
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
MAX	.000	.000	.846	4.772	5.530	3.902	2.075	1.029	.420	.173	.000	.000	26294
MEAN	.000	.000	.054	1.418	.644	.225	.100	.032	.009	.003	.000	.000	6515

Table D-7

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA7 ASIN D7
SHELL RIVER NEAR ROBLIN (05MD007)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.250	.206	.228	2.249	2.124	1.455	.625	.375	.397	.581	.669	.309	24890
1942	.294	.272	.375	5.976	3.161	3.102	1.793	1.433	1.521	1.749	1.374	.603	56891
1943	.478	.419	.478	7.534	4.373	3.910	2.102	1.044	.794	.978	1.044	.544	62212
1944	.456	.397	.397	.919	1.874	1.455	.933	.478	.581	.794	.919	.456	25464
1945	.397	.331	.456	2.727	3.557	2.352	2.021	.956	.875	1.102	1.080	.522	43167
1946	.419	.375	.559	4.785	2.874	1.602	1.749	.669	.559	.875	1.147	.603	42632
1947	.500	.419	.456	5.660	7.850	5.726	6.615	2.058	1.896	2.124	1.749	1.044	95272
1948	.772	.603	.706	8.526	21.756	4.542	8.453	6.159	2.065	1.521	1.139	.794	151255
1949	.603	.559	.339	3.815	2.183	3.454	1.793	1.720	.919	.845	.941	.522	46453
1950	.434	.353	.434	3.454	7.240	4.866	4.197	2.528	.948	1.632	1.294	.434	73489
1951	.309	.272	.309	6.769	13.010	3.205	2.742	2.051	3.690	4.160	2.624	.750	105359
1952	.478	.419	.500	7.571	4.145	2.690	1.411	.838	1.330	1.477	1.007	.434	58567
1953	.309	.250	.331	4.792	6.630	7.718	14.333	3.881	4.065	3.322	3.932	1.602	135199
1954	1.022	.809	1.022	5.013	11.025	22.197	10.290	2.374	3.844	4.947	3.138	1.808	177595
1955	1.227	.978	1.205	12.348	12.863	5.549	3.175	1.051	.772	1.073	1.227	.750	111105
1956	.603	.544	.794	3.513	10.584	4.792	5.241	2.021	1.815	1.433	1.294	.978	88945
1957	.992	.786	.684	6.733	11.099	2.881	1.529	1.029	.860	.963	1.000	.651	77030
1958	.308	.271	.550	2.955	1.624	1.161	.742	.417	.867	1.161	1.316	.504	31196
1959	.495	.328	1.110	4.028	4.439	3.219	3.859	.801	1.036	1.970	1.815	1.264	64300
1960	.665	.757	.801	7.791	6.343	7.049	1.492	.479	.252	.388	.750	.414	71302
1961	.535	.398	.370	1.088	1.014	.581	.299	.105	.090	.237	.609	.505	15309
1962	.604	.750	.757	1.713	1.801	.978	.236	.284	.351	.623	.659	.583	24492
1963	.419	.303	.375	2.420	2.670	1.370	.828	.429	.402	.521	.480	.308	27708
1964	.301	.253	.227	2.210	2.870	.565	.355	.338	.319	.522	.709	.180	23329
1965	.062	.088	.143	3.950	7.500	4.750	1.450	1.190	1.260	2.140	.983	.880	64374
1966	.716	.629	.849	5.600	10.500	6.500	4.370	.713	.368	.505	.642	.588	84359
1967	.560	.441	.341	2.000	7.510	3.650	.897	.470	.235	.441	.502	.478	46273
1968	.534	.510	.642	2.490	1.130	.958	.768	.836	.638	.579	.838	.657	27824
1969	.508	.512	.522	4.840	2.080	1.320	1.750	1.260	.456	2.140	1.220	.711	45577
1970	.565	.534	.523	3.220	16.800	3.090	2.890	2.360	.509	1.410	3.720	1.260	97733
1971	.873	.656	.600	13.500	4.880	2.680	2.040	1.680	.370	.922	1.330	1.130	80408
1972	.816	.724	.777	6.970	13.600	1.970	1.970	.580	.400	.613	.523	.447	77741
1973	.204	.173	.763	2.210	1.810	2.360	2.760	.674	1.130	1.280	1.080	1.010	40761
1974	.606	.490	.869	9.350	18.800	7.880	1.920	.934	1.230	2.070	1.300	.926	122377
1975	.765	.640	.850	6.140	15.700	8.910	2.470	.946	1.200	2.180	2.040	.954	112876
1976	.742	.776	.881	12.700	4.720	18.600	5.800	1.270	.629	.745	.609	.413	125310
1977	.268	.365	.463	2.870	2.170	1.080	1.521	1.102	2.499	3.116	1.691	.992	47783
1978	.801	.548	.845	4.280	3.890	1.750	1.154	.440	.601	1.022	1.036	.553	44512
1979	.384	.367	.575	5.210	19.700	8.640	1.536	.553	.663	.614	1.147	.592	105634
1980	.548	.553	.667	5.350	1.840	.686	.612	.711	.651	.867	.904	.390	36153
1981	.248	.311	1.300	2.670	1.720	1.490	1.058	.637	.430	.948	.978	.370	32011
1982	.159	.273	.194	2.910	2.280	1.120	3.013	1.823	.362	.882	.985	.514	38341
1983	.602	.611	.606	4.160	10.000	5.970	4.550	.867	.525	.941	1.147	.708	81011
1984	.431	.520	1.260	5.200	7.390	7.000	3.520	.556	.563	1.646	.882	1.470	80257
1985	.838	.628	.865	8.290	4.970	3.810	1.691	3.190	1.838	2.315	1.352	1.029	81052
1986	1.117	.875	1.020	10.700	8.310	2.360	2.500	1.147	.545	2.293	1.154	.897	86663
1987	.786	.577	1.560	8.120	2.480	2.840	3.860	1.396	.735	1.352	1.477	1.110	69140
1988	.509	.529	.757	13.200	27.700	3.660	1.290	.596	.309	.532	.545	.495	132622
1989	.441	.450	.242	1.410	.911	2.400	1.676	.566	.897	1.176	1.536	.875	33036
1990	.623	.717	1.000	9.820	13.700	3.900	1.720	.590	.407	.529	.612	.457	89807
1991	.384	.429	.640	2.210	2.340	2.650	4.241	1.110	.479	.537	.801	.671	43533
1992	.638	.616	.955	2.700	3.420	1.490	.786	.474	.732	1.095	.933	.750	38465
1993	.646	.331	.611	1.870	1.640	.878	7.210	2.117	2.793	1.757	1.286	.985	58580
1994	.757	.678	.928	5.470	1.540	3.058	13.671	5.998	2.962	1.485	1.117	.853	101897
1995	.875	.620	1.340	8.890	25.600	6.784	2.550	3.557	1.764	1.279	1.183	.882	146411
MIN	.062	.088	.143	.919	.911	.565	.236	.105	.090	.237	.480	.180	15309
MAX	1.227	.978	1.560	13.500	27.700	22.197	14.333	6.159	4.065	4.947	3.932	1.808	177595
MEAN	.561	.495	.674	5.325	7.159	4.012	2.983	1.343	1.062	1.353	1.227	.738	71012

Table D-8

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA8 ASIN D8
GOOD SPIRIT LAKE NEAR CANORA (05MB010)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	1.613	.273	.000	.000	.000	.000	.000	.000	.000	4912
1942	.000	.000	.062	4.089	.469	1.086	.340	.000	.000	.000	.000	.000	15744
1943	.000	.000	.000	5.119	1.160	.730	.508	.000	.000	.000	.000	.000	19628
1944	.000	.000	.000	.355	.184	.129	.062	.000	.000	.000	.000	.000	1914
1945	.000	.000	.055	.855	.523	.308	.172	.000	.000	.000	.000	.000	5024
1946	.000	.000	.109	1.800	.410	.152	.000	.000	.000	.000	.000	.000	6452
1947	.000	.000	.000	2.944	2.425	.672	.000	.000	.000	.000	.000	.000	15868
1948	.000	.000	.000	2.894	9.598	.761	.320	.000	.000	.000	.000	.000	36040
1949	.000	.000	.000	2.855	.230	.683	.184	.000	.000	.000	.000	.000	10279
1950	.000	.000	.000	1.894	1.265	.320	.000	.000	.000	.000	.000	.000	9128
1951	.000	.000	.000	2.726	4.167	.855	.398	.000	.000	.000	.000	.000	21508
1952	.000	.000	.000	4.877	1.593	.457	.000	.000	.000	.000	.000	.000	18094
1953	.000	.000	.000	2.234	2.140	2.745	8.103	4.018	1.640	.676	.000	.000	57163
1954	.000	.000	.000	4.249	8.341	15.237	5.006	1.222	.000	.000	.000	.000	89531
1955	.000	.000	.074	12.297	17.401	4.327	1.648	.625	.305	.000	.000	.000	96770
1956	.000	.000	.000	5.947	16.506	3.987	1.418	.410	.000	.000	.000	.000	74855
1957	.000	.000	.000	9.294	21.595	8.005	.000	.000	.000	.000	.000	.000	102679
1958	.000	.000	.430	1.515	.336	.000	.000	.000	.000	.000	.000	.000	5977
1959	.000	.000	.656	1.211	.211	.000	.000	.000	.000	.000	.000	.000	5460
1960	.000	.000	.176	6.990	.707	.000	.000	.000	.000	.000	.000	.000	20482
1961	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1962	.000	.000	.000	4.608	.457	.160	.000	.000	.000	.000	.000	.000	13582
1963	.000	.000	.199	.109	.000	.000	.000	.000	.000	.000	.000	.000	817
1964	.000	.000	.000	1.172	.121	.000	.000	.000	.000	.000	.000	.000	3361
1965	.000	.000	.000	2.968	.277	.371	.160	.000	.000	.039	.000	.000	9930
1966	.000	.000	.000	8.747	1.835	.055	.008	.070	.012	.000	.000	.000	27970
1967	.000	.000	.000	4.296	4.803	.070	.000	.000	.000	.000	.000	.000	24181
1968	.000	.000	1.449	.547	.039	.008	.000	.000	.000	.000	.000	.000	5422
1969	.000	.000	.000	3.800	.023	.008	.074	.008	.000	.000	.000	.000	10151
1970	.000	.000	.000	3.780	1.238	.012	.008	.000	.000	.000	.000	.000	13165
1971	.000	.000	.000	10.192	.102	.031	.000	.004	.000	.000	.000	.000	26781
1972	.000	.000	.000	16.050	1.695	.004	.000	.000	.000	.000	.000	.000	46150
1973	.000	.000	.293	.465	.102	.664	.102	.000	.000	.000	.000	.000	4254
1974	.000	.000	.000	12.145	8.435	1.039	.004	.000	.000	.000	.000	.000	56773
1975	.000	.000	.000	11.871	4.335	.090	.000	.000	.000	.000	.000	.000	42613
1976	.000	.000	.000	18.432	.180	.570	.105	.000	.000	.000	.000	.000	50016
1977	.000	.000	.000	2.035	.008	.000	.000	.000	.000	.000	.000	.000	5294
1978	.000	.000	.000	2.081	.059	.012	.570	.000	.000	.000	.000	.000	7109
1979	.000	.000	.000	14.722	5.897	.269	.004	.000	.000	.000	.000	.000	54661
1980	.000	.000	.000	5.194	.008	.000	.000	.000	.000	.000	.000	.000	13483
1981	.000	.000	.359	.008	.000	.000	.027	.000	.000	.023	.000	.000	1118
1982	.000	.000	.086	2.265	.012	.000	.004	.000	.000	.000	.000	.000	6143
1983	.000	.000	.000	7.068	1.238	.078	.082	.012	.004	.000	.000	.000	22100
1984	.000	.000	3.304	1.835	.082	.363	.039	.000	.004	.004	.000	.000	14892
1985	.000	.000	.000	17.807	.492	.004	.000	.000	.000	.000	.000	.000	47483
1986	.000	.000	2.800	7.732	.070	.000	.016	.070	.000	.000	.000	.000	27959
1987	.000	.000	.031	7.185	.102	.125	.000	.000	.000	.000	.000	.000	19304
1988	.000	.000	.000	14.292	.297	.000	.000	.000	.000	.000	.000	.000	37841
1989	.000	.000	.000	.004	.004	.000	.000	.000	.000	.000	.000	.000	21
1990	.000	.000	.480	14.488	.246	.004	.000	.000	.000	.000	.000	.000	39507
1991	.000	.000	.000	1.445	.020	.004	.000	.000	.000	.000	.000	.000	3807
1992	.000	.000	.000	10.153	.226	.000	.000	.000	.000	.000	.000	.000	26923
1993	.000	.000	.133	.379	.199	.113	.000	.000	.000	.000	.000	.000	2164
1994	.000	.000	.668	2.214	.871	.988	.722	.000	.000	.000	.000	.000	14356
1995	.000	.000	.184	18.635	15.354	2.851	1.433	.492	.000	.000	.000	.000	102463
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
MAX	.000	.000	3.304	18.635	21.595	15.237	8.103	4.018	1.640	.676	.000	.000	102679
MEAN	.000	.000	.210	5.536	2.516	.879	.391	.126	.036	.013	.000	.000	25442

Table D-9

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA9 ASIN D9
LITTLE BOGGY CREEK NEAR COTE (05MD006)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.161	.507	.373	.005	.039	.045	.104	.000	.000	.000	3252
1942	.000	.119	.310	.592	.445	.183	.229	.157	.171	.318	.013	.000	6681
1943	.000	.000	.166	1.154	.939	.777	.189	.171	.114	.115	.059	.000	9685
1944	.000	.000	.123	.820	.334	.241	.180	.094	.173	.142	.022	.000	5594
1945	.000	.129	.281	1.095	.956	.414	.518	.235	.207	.286	.230	.064	11624
1946	.000	.000	.338	2.350	.643	.258	.494	.111	.120	.240	.037	.000	12058
1947	.000	.000	.148	2.193	2.719	1.867	2.580	.454	.476	.420	.203	.000	29214
1948	.000	.000	.167	1.976	6.567	.863	.547	.453	.165	.094	.000	.000	28753
1949	.000	.000	.122	.000	.282	.484	.294	.232	.131	.168	.180	.080	5216
1950	.000	.000	.215	.929	1.148	.369	.238	.190	.152	.186	.036	.000	9147
1951	.000	.000	.131	.801	.912	.465	.324	.309	.198	.000	.000	.000	8284
1952	.000	.000	.144	.883	.483	.226	.195	.160	.172	.160	.069	.000	6558
1953	.000	.000	.252	1.396	.352	.253	.000	1.007	.315	.368	.319	.369	12206
1954	.254	.212	.162	.131	.728	.000	4.853	.505	.266	.430	1.260	.555	24861
1955	.151	.167	.128	.691	2.719	3.313	.611	.431	.090	.106	.094	.000	22364
1956	.000	.000	.000	.000	5.802	3.027	.863	.569	.309	.290	.177	.000	29258
1957	.000	.000	.000	2.480	1.250	.391	.203	.095	.040	.055	.000	.000	11839
1958	.000	.000	.039	.437	.316	.215	.165	.119	.246	.356	.109	.000	5275
1959	.000	.000	.672	.946	.395	.390	.202	.237	.333	.429	.192	.083	10229
1960	.000	.000	.046	2.280	.730	.569	.163	.071	.089	.103	.063	.000	10760
1961	.000	.000	.068	.246	.280	.120	.048	.005	.004	.034	.000	.000	2124
1962	.000	.000	.018	1.050	.456	.216	.079	.056	.070	.083	.046	.000	5436
1963	.000	.000	.923	.474	.309	.258	.550	.136	.125	.176	.114	.000	8125
1964	.000	.000	.000	.651	.375	.138	.150	.125	.118	.167	.028	.000	4612
1965	.000	.000	.025	1.380	.493	.364	.186	.056	.156	.284	.005	.000	7734
1966	.000	.000	.049	1.580	.489	.638	.231	.196	.093	.057	.000	.000	8727
1967	.000	.000	.000	.798	.700	.188	.074	.043	.027	.078	.025	.000	5088
1968	.000	.077	.164	.669	.226	.172	.227	.170	.111	.189	.000	.000	5275
1969	.000	.000	.000	.871	.237	.064	.096	.090	.101	.172	.080	.000	4486
1970	.000	.000	.000	.877	.465	.081	.242	.029	.089	.283	.000	.000	5143
1971	.000	.000	.084	2.090	.269	.072	.234	.132	.026	.134	.025	.000	8021
1972	.000	.000	.030	2.340	.423	.055	.064	.042	.063	.118	.000	.000	8184
1973	.000	.048	.242	.433	.237	.718	.113	.102	.104	.103	.034	.000	5592
1974	.000	.000	.535	4.838	1.369	.630	.018	.069	.092	.000	.000	.000	19744
1975	.000	.000	.128	1.836	1.059	.411	.000	.457	.182	.174	.089	.000	11396
1976	.000	.000	.344	3.789	.761	.031	.000	.098	.000	.000	.000	.000	13124
1977	.000	.171	.508	.433	.479	.000	.093	.000	.284	.077	.000	.000	5371
1978	.000	.000	.000	1.619	.338	.073	.000	.214	.222	.148	.068	.000	7012
1979	.000	.000	.038	2.853	2.566	.884	.651	.275	.525	.000	.000	.000	20502
1980	.000	.000	.027	1.720	.301	.247	.202	.130	.212	.163	.050	.000	7982
1981	.000	.094	.299	.545	.294	.204	.125	.030	.030	.137	.075	.000	4811
1982	.000	.000	.005	.891	.375	.050	.692	.000	.016	.021	.000	.000	5408
1983	.000	.000	.252	1.762	1.776	.812	.537	.761	.326	.000	.000	.000	16425
1984	.000	.052	.526	.873	.544	.595	.476	.060	.129	.035	.000	.000	8665
1985	.000	.000	.004	3.592	1.109	.624	.165	.244	.071	.106	.033	.000	15558
1986	.000	.000	.268	4.095	.729	.271	.351	.285	.000	.211	.033	.000	16341
1987	.000	.000	.442	2.546	.411	.327	.239	.042	.070	.163	.021	.000	11157
1988	.000	.000	.484	2.584	1.086	.595	.285	.238	.000	.160	.039	.000	14375
1989	.000	.143	.191	.667	.277	.165	.167	.264	.096	.059	.000	.000	5317
1990	.000	.000	.101	3.802	.695	.756	.384	.142	.112	.000	.000	.000	15645
1991	.000	.000	.170	1.837	.552	.337	.640	.000	.000	.031	.000	.000	9366
1992	.000	.000	.118	2.632	.800	.291	.120	.075	.021	.170	.088	.000	11295
1993	.000	.064	.380	.509	.328	.104	.436	.235	.305	.011	.000	.000	6257
1994	.000	.043	.518	.802	.406	.613	.589	.435	.303	.079	.000	.000	9986
1995	.000	.000	.696	8.197	4.979	.514	.495	.739	.417	.177	.036	.000	42732
MIN	.000	.000	.000	.000	.226	.000	.000	.000	.000	.000	.000	.000	2124
MAX	.254	.212	.923	8.197	6.567	3.313	4.853	1.007	.525	.430	1.260	.555	42732
MEAN	.007	.024	.204	1.592	.987	.471	.397	.211	.152	.147	.072	.021	11276

Table D-10

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA10 ASIN D10
THEODORE RESERVOIR NEAR THEODORE (05MB009)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	1.344	.274	.176	.000	.000	.000	.000	.000	.000	4672
1942	.000	.000	.065	3.143	.398	1.108	.350	.368	.356	.256	.053	.000	15923
1943	.000	.000	.000	3.258	.655	.473	.201	.147	.087	.077	.056	.000	12938
1944	.000	.000	.000	.147	.109	.086	.012	.000	.000	.000	.000	.000	931
1945	.000	.000	.000	.278	.152	.110	.057	.000	.010	.026	.000	.000	1661
1946	.000	.000	.048	.875	.142	.042	.019	.001	.019	.059	.000	.000	3146
1947	.000	.000	.000	2.398	2.452	.504	.343	.043	.037	.050	.000	.000	15356
1948	.000	.000	.000	7.381	6.404	.294	.180	.041	.001	.002	.000	.000	37649
1949	.000	.000	.000	.000	.048	.000	.011	.024	.023	.000	.000	.000	280
1950	.000	.000	.029	1.736	.707	.109	.058	.049	.000	.000	.000	.000	7040
1951	.000	.000	.000	1.814	2.840	.329	.120	.015	.057	.125	.093	.000	14246
1952	.000	.000	.003	2.885	.377	.076	.008	.000	.000	.000	.000	.000	8715
1953	.000	.000	.020	1.773	.960	1.914	5.941	2.813	.861	.394	.490	.086	40412
1954	.046	.034	.054	5.776	4.020	14.248	3.907	1.050	1.365	1.718	.761	.236	87043
1955	.099	.086	.077	12.972	20.072	4.624	2.428	.967	.255	.282	.169	.128	111343
1956	.075	.062	.066	9.199	15.270	3.636	1.568	.364	.171	.188	.253	.000	81478
1957	.000	.000	.000	5.642	3.924	.717	.233	.099	.029	.000	.000	.000	27956
1958	.000	.000	.064	1.074	.248	.043	.000	.000	.000	.000	.000	.000	3732
1959	.000	.000	.000	.549	.042	.024	.091	.000	.000	.007	.000	.000	1860
1960	.000	.000	.036	3.958	1.327	.587	.255	.001	.000	.000	.000	.000	16118
1961	.000	.000	.000	.059	.020	.000	.000	.000	.000	.000	.000	.000	205
1962	.000	.000	.000	2.205	.539	.021	.000	.000	.000	.000	.000	.000	7212
1963	.000	.000	.031	.156	.003	.014	.000	.000	.000	.000	.000	.000	531
1964	.000	.000	.000	.000	.185	.017	.000	.000	.000	.120	.097	.000	1112
1965	.000	.000	.000	1.619	.700	.686	.093	.028	.009	.054	.000	.000	8338
1966	.000	.000	.000	4.366	2.044	.638	.569	.453	.044	.104	.000	.000	21577
1967	.000	.000	.000	1.032	4.010	.388	.009	.002	.003	.194	.024	.000	15037
1968	.000	.000	.154	.463	.051	.029	.000	.000	.042	.000	.000	.000	1935
1969	.000	.000	.000	2.106	.367	.033	.026	.028	.000	.081	.050	.000	7020
1970	.000	.000	.000	2.874	2.919	.535	.487	.022	.000	.241	.092	.000	18905
1971	.000	.000	.024	7.206	1.108	.731	.511	.069	.000	.007	.000	.000	25175
1972	.000	.000	.008	7.261	2.339	.125	.008	.000	.000	.000	.000	.000	25455
1973	.000	.000	.066	.122	.106	.515	.196	.000	.064	.000	.000	.000	2800
1974	.000	.000	.014	5.666	6.301	2.593	.125	.082	.090	.064	.025	.000	39345
1975	.000	.000	.039	6.339	12.351	1.766	.607	.158	.171	.119	.232	.113	57908
1976	.060	.056	.073	14.176	3.262	2.850	2.679	.501	.141	.054	.032	.000	62472
1977	.000	.000	.022	.377	.425	.003	.000	.000	.000	.000	.000	.000	2185
1978	.000	.000	.000	.751	.127	.000	.214	.012	.000	.000	.000	.000	2893
1979	.000	.000	.002	5.944	8.939	1.245	.100	.014	.090	.050	.058	.000	43404
1980	.000	.000	.000	2.240	.583	.060	.000	.000	.000	.005	.000	.000	7537
1981	.000	.000	.069	.051	.032	.222	.100	.006	.000	.152	.219	.085	2464
1982	.032	.024	.010	1.063	.360	.134	.494	.024	.000	.000	.000	.000	5627
1983	.000	.000	.023	3.409	3.351	1.128	1.862	.346	.000	.000	.000	.000	26715
1984	.000	.000	.216	.981	.580	.291	.082	.000	.000	.037	.000	.000	5747
1985	.000	.000	.021	12.036	3.015	.998	.307	.085	.039	.058	.040	.000	43327
1986	.000	.000	.590	6.959	1.856	.665	.449	.113	.000	.000	.000	.000	27820
1987	.000	.000	.000	1.880	.497	.084	.204	.000	.000	.000	.000	.000	6968
1988	.000	.143	.145	2.902	2.747	.689	.000	.000	.000	.000	.000	.000	17416
1989	.000	.000	.000	.038	.001	.046	.000	.000	.000	.000	.056	.006	381
1990	.000	.000	.000	5.985	1.526	.002	.000	.000	.000	.000	.041	.024	19779
1991	.000	.000	.000	.398	.064	.000	.000	.000	.000	.000	.016	.016	1288
1992	.000	.000	.000	1.152	.806	.007	.307	.000	.064	.000	.000	.000	6153
1993	.000	.008	.061	.113	.007	.071	1.530	.136	.111	.027	.000	.000	5501
1994	.000	.000	1.019	2.133	.761	.995	2.476	.128	.069	.068	.080	.042	20532
1995	.018	.020	.405	23.458	15.332	3.389	.000	.484	.851	1.005	.926	.367	121409
MIN	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	205
MAX	.099	.143	1.019	23.458	20.072	14.248	5.941	2.813	1.365	1.718	.926	.367	121409
MEAN	.006	.008	.063	3.522	2.504	.910	.531	.158	.092	.102	.070	.020	20994

Table D-11

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA11 WHITESAND RIVER NEAR CANORA (05MB003)

ASIN D11

(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	4.837	.818	.513	.000	.000	.000	.000	.000	.000	16058
1942	.000	.000	.189	12.244	1.409	3.250	1.019	1.312	1.038	.745	.154	.000	55769
1943	.000	.000	.000	12.500	2.230	1.550	.627	.440	.255	.224	.162	.000	46929
1944	.000	.000	.000	1.120	.328	.272	.035	.000	.000	.000	.000	.000	4580
1945	.000	.000	.520	1.270	.454	.321	.246	.001	.028	.075	.000	.000	7668
1946	.000	.000	1.490	2.750	.425	.123	.054	.003	.055	.172	.000	.000	13332
1947	.000	.000	.000	12.100	8.280	1.620	1.070	.126	.109	.147	.000	.000	61619
1948	.000	.000	.000	27.200	23.900	.936	.726	.130	.004	.007	.000	.000	139264
1949	.000	.000	.000	1.370	.160	.880	.081	.070	.066	.000	.000	.000	6836
1950	.000	.000	.085	8.230	2.170	.328	.190	.144	.000	.000	.000	.000	29117
1951	.000	.000	.000	8.890	8.820	.988	.380	.063	.186	.395	.270	.000	52654
1952	.000	.000	.050	9.710	1.110	.233	.022	.000	.000	.000	.000	.000	28938
1953	.000	.000	.058	8.180	2.930	6.870	20.300	8.940	2.880	1.460	1.430	.251	141083
1954	.135	.100	.158	19.000	13.800	48.500	17.500	5.730	6.480	7.730	4.320	.687	325706
1955	.289	.251	.224	50.400	74.600	20.600	10.700	4.010	.882	.982	.494	.374	432420
1956	.220	.181	.193	36.900	64.600	17.600	6.760	1.930	1.380	.817	.737	.000	346799
1957	.000	.000	.000	23.000	14.100	2.480	.858	.408	.185	.000	.000	.000	107680
1958	.000	.000	.247	3.240	.724	.126	.000	.000	.000	.000	.000	.000	11325
1959	.000	.000	.521	1.900	.131	.081	.286	.000	.000	.051	.000	.000	7784
1960	.000	.000	.106	19.700	3.990	1.770	.743	.003	.000	.000	.000	.000	68619
1961	.000	.000	.000	.181	.058	.000	.000	.000	.000	.000	.000	.000	624
1962	.000	.000	.000	7.990	1.720	.130	.000	.000	.000	.000	.000	.000	25654
1963	.000	.000	.259	.575	.038	.062	.019	.001	.000	.000	.000	.000	2500
1964	.000	.000	.000	.858	.580	.049	.000	.000	.000	.350	.282	.000	5573
1965	.000	.000	.000	7.840	2.270	2.090	.311	.121	.066	.186	.000	.000	33645
1966	.000	.000	.000	17.800	6.480	1.920	1.700	1.340	.138	.323	.000	.000	77835
1967	.000	.000	.000	3.770	12.300	1.140	.026	.005	.008	.586	.069	.000	47523
1968	.000	.000	.580	1.920	.208	.136	.003	.002	.153	.000	.000	.000	7850
1969	.000	.000	.000	9.000	1.170	.117	.127	.131	.021	.285	.147	.000	28655
1970	.000	.000	.000	10.500	9.140	1.590	1.640	.075	.000	.754	.268	.000	63125
1971	.000	.000	.071	24.500	3.390	2.490	1.710	.210	.000	.039	.000	.000	84475
1972	.000	.000	.174	27.800	7.130	.414	.044	.001	.000	.000	.000	.000	92814
1973	.000	.000	.372	.426	.319	1.710	.710	.001	.337	.005	.000	.000	10179
1974	.000	.000	.060	24.800	21.400	8.020	.725	.579	.513	.336	.072	.000	148457
1975	.000	.000	.113	24.300	41.400	8.110	3.160	1.140	1.000	.736	.676	.328	213906
1976	.174	.162	.303	52.500	12.900	11.200	9.170	1.850	.580	.207	.093	.000	233160
1977	.000	.000	.085	1.710	1.530	.109	.000	.000	.000	.000	.000	.000	9040
1978	.000	.000	.000	3.350	.509	.032	.635	.066	.001	.006	.000	.000	12026
1979	.000	.000	.005	22.500	28.300	3.700	.842	.381	.503	.326	.168	.000	149611
1980	.000	.000	.003	12.100	1.990	.294	.082	.044	.019	.036	.000	.000	37946
1981	.000	.000	.261	.190	.173	.856	.683	.428	.019	.642	.638	.247	10933
1982	.092	.070	.059	4.060	1.140	.432	1.800	.151	.014	.060	.000	.000	20693
1983	.000	.000	.076	13.300	9.890	3.290	6.690	1.100	.039	.025	.000	.000	90727
1984	.000	.000	1.280	3.250	1.980	.989	.258	.000	.000	.208	.000	.000	20967
1985	.000	.000	.060	37.000	10.900	3.600	.925	.269	.143	.190	.118	.000	138974
1986	.000	.000	1.720	21.400	5.840	2.060	1.380	.359	.008	.006	.000	.000	85752
1987	.000	.000	.751	6.100	1.500	.364	.795	.022	.004	.001	.000	.000	24985
1988	.000	.448	.574	9.630	8.480	2.030	.004	.001	.000	.000	.000	.000	55609
1989	.000	.000	.000	.390	.103	.295	.024	.000	.000	.000	.162	.018	2584
1990	.000	.000	.000	21.100	4.720	.076	.027	.000	.000	.003	.120	.070	68109
1991	.000	.000	.000	2.140	.407	.101	.066	.018	.000	.000	.048	.046	7371
1992	.000	.000	.078	5.610	2.830	.061	.916	.022	.386	.070	.000	.000	26188
1993	.000	.044	.398	.478	.190	.328	4.460	.467	.474	.199	.000	.000	18729
1994	.000	.000	2.970	6.220	2.490	2.900	7.220	.504	.371	.319	.232	.121	61693
1995	.052	.058	1.180	76.400	51.700	12.900	1.380	2.810	2.970	3.820	2.881	1.201	413216
MIN	.000	.000	.000	.181	.038	.000	.000	.000	.000	.000	.000	.000	624
MAX	.289	.448	2.970	76.400	74.600	48.500	20.300	8.940	6.480	7.730	4.320	1.201	432420
MEAN	.017	.024	.278	13.204	8.730	3.321	1.984	.644	.388	.410	.246	.061	77006

Table D-12

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA12 ASIN D12
ASSINIBOINE RIVER AT KAMSACK WEIR
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.050	.050	.065	6.650	1.125	.706	.000	.000	.008	.000	.007	.071	22740
1942	.021	.014	.260	16.836	1.937	4.469	1.401	1.805	1.428	1.024	.213	.080	77000
1943	.080	.048	.105	23.118	5.672	3.465	2.737	.605	.350	.308	.223	.145	96354
1944	.032	.040	.057	1.401	.937	.564	.355	.108	.120	.134	.323	.105	10967
1945	.024	.048	.000	4.526	3.052	1.747	.968	.251	.241	.408	.303	.097	30647
1946	.048	.048	.000	9.169	2.326	.981	.522	.224	.213	.228	1.023	.161	39029
1947	.057	.065	.080	8.563	8.863	3.029	3.354	.734	.672	.866	.790	.331	72248
1948	.217	.161	.169	.000	42.055	4.054	1.401	.718	.218	.330	.572	.226	133799
1949	.113	.024	.040	15.102	1.537	4.295	1.186	.371	.083	.155	.529	.150	61434
1950	.071	.071	.117	5.645	6.435	1.846	.730	2.126	.467	.297	.846	.258	49866
1951	.161	.121	.105	10.634	20.774	5.007	2.419	1.128	3.211	7.261	2.459	.290	141607
1952	.105	.089	.091	25.488	9.802	2.896	1.018	.316	.188	.246	.427	.137	106768
1953	.072	.089	.080	7.758	12.469	14.974	38.001	20.105	9.028	3.258	2.643	.345	288469
1954	.186	.138	.218	11.757	44.658	62.532	16.841	3.307	5.531	5.226	3.005	.945	406199
1955	.398	.345	.308	39.798	53.411	10.575	1.822	.696	1.116	1.021	.680	.515	291861
1956	.303	.250	.265	7.859	54.546	11.235	3.472	1.063	.866	.872	1.014	.790	219208
1957	.363	.314	.338	17.456	25.494	2.666	.819	.572	.756	.185	.201	.282	130529
1958	.145	.258	.110	4.542	1.526	.524	.130	.043	.043	.078	.278	.057	20182
1959	.050	.036	.491	3.100	1.205	.307	.262	.144	.211	.568	.443	.177	18375
1960	.135	.157	.031	29.963	13.216	7.222	2.658	.153	.051	.036	.135	.171	141185
1961	.128	.064	.175	.579	.631	.286	.014	.007	.007	.007	.007	.007	5033
1962	.007	.007	.014	10.262	4.428	.845	.193	.014	.057	.043	.064	.007	41725
1963	.007	.007	.567	5.314	1.198	.895	.424	.071	.007	.043	.029	.029	22468
1964	.029	.029	.029	3.700	4.100	.666	.266	.298	.637	.339	.387	.234	28223
1965	.164	.143	.128	16.159	6.885	18.381	5.116	1.082	1.095	2.422	1.239	.524	139638
1966	.467	.314	.776	32.603	15.533	6.347	4.040	3.190	1.347	.304	.685	.597	173696
1967	.419	.331	.267	7.398	26.539	4.213	.604	.267	.151	.000	.079	.143	107125
1968	.114	.135	.899	5.822	.902	.584	.414	.457	.279	.183	.145	.129	26345
1969	.113	.072	.130	15.549	3.194	.973	.484	.416	.171	.346	.201	.121	56834
1970	.072	.072	.072	10.259	17.491	4.230	1.928	.859	.156	.235	1.413	.637	98831
1971	.323	.266	.248	38.600	11.826	3.524	1.280	1.583	.248	.496	.758	.774	156706
1972	.500	.274	.483	34.406	46.125	2.976	.756	.332	.147	.269	.234	.129	228720
1973	.089	.080	.347	4.735	4.866	6.351	6.569	.986	.040	.260	.338	.467	66293
1974	.298	.298	.268	21.654	43.333	19.242	1.423	.493	1.100	1.416	1.351	1.241	242905
1975	.669	.597	.441	20.363	41.821	10.223	3.165	.380	.424	.672	.928	.451	211718
1976	.239	.223	.468	43.861	11.304	10.087	9.814	1.279	.225	.289	.546	.548	206513
1977	.346	.331	.345	7.533	2.378	.652	.256	.226	.148	.363	.395	.355	34854
1978	.234	.171	.226	11.141	5.488	.797	.955	.212	.113	.207	.580	.482	54049
1979	.358	.277	.225	18.745	56.417	9.458	1.086	.258	.085	.066	.231	.395	232097
1980	.382	.320	.306	14.274	2.606	.376	.388	.085	.134	.264	.418	.274	51737
1981	.168	.164	1.345	4.595	1.471	.600	.521	.332	.148	.795	.877	.340	29835
1982	.126	.096	.249	5.748	2.823	.981	2.473	.403	.076	.205	.297	.181	35941
1983	.212	.247	.185	11.450	19.893	4.570	4.094	1.561	.267	.165	.489	.517	115400
1984	.326	.318	2.574	10.988	4.825	6.806	1.644	.350	.066	.062	.656	.554	76471
1985	.302	.281	.248	35.540	13.872	2.409	.612	.262	.163	.339	.371	.324	143175
1986	.321	.368	.447	32.456	5.318	1.518	.918	.463	.100	.217	.345	.377	111695
1987	.343	.346	.813	19.789	2.602	1.203	.984	.528	.223	.325	.592	.685	74183
1988	1.683	.940	.986	30.519	15.630	1.858	.515	.229	.143	.111	.168	.188	138887
1989	.137	.134	.163	2.397	.830	.708	.746	.214	.236	.169	.276	.234	16375
1990	.237	.187	.217	17.144	5.272	1.549	.454	.261	.182	.084	.000	.079	67062
1991	.099	.122	.156	2.876	1.279	.460	1.222	.281	.090	.058	.128	.133	18154
1992	.122	.207	.207	11.244	3.653	.786	.006	.240	.000	.252	.268	.212	44965
1993	.178	.135	.525	2.009	1.043	.434	9.405	9.398	10.674	3.569	1.881	1.057	106630
1994	.758	.475	1.949	9.668	3.760	3.962	3.555	.645	.312	.414	.527	.583	69894
1995	.490	.497	.286	57.681	54.714	8.354	8.976	12.070	4.768	1.802	3.962	1.652	409239
MIN	.007	.007	.000	.000	.631	.286	.000	.000	.000	.000	.000	.007	5033
MAX	1.683	.940	2.574	57.681	56.417	62.532	38.001	20.105	10.674	7.261	3.962	1.652	409239
MEAN	.238	.198	.358	15.026	13.729	5.098	2.825	1.349	.888	.714	.672	.364	109125

Table D-13

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA13 ASIN D13
LAKE OF THE PRAIRIES NEAR SHELLMOUTH (05MD009)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	1.160	1.219	1.378	18.703	7.298	3.340	1.088	.785	1.189	.463	1.351	1.137	102317
1942	1.069	1.118	2.902	43.483	10.684	13.762	6.484	6.316	5.808	6.264	2.352	1.373	266226
1943	1.508	1.343	1.798	57.078	20.726	15.760	7.969	3.608	2.438	2.616	2.204	1.693	310993
1944	1.306	1.303	1.368	9.048	6.021	4.449	2.877	1.370	2.012	2.129	1.784	1.560	92631
1945	1.187	1.305	2.774	17.074	14.780	8.121	7.250	3.051	2.781	3.843	3.292	1.224	175560
1946	1.373	1.313	3.683	34.919	11.035	4.953	6.051	1.894	1.756	3.061	6.129	1.808	204380
1947	1.315	1.356	1.626	44.013	46.185	24.474	29.701	6.576	6.360	6.618	4.608	3.078	463945
1948	2.197	1.815	2.195	46.183	144.393	17.388	17.338	12.189	4.110	3.090	3.248	1.925	679417
1949	1.963	1.355	1.261	26.089	6.481	12.982	5.665	4.277	2.222	2.383	3.127	1.410	181198
1950	1.478	1.382	2.133	25.096	26.711	11.356	8.194	6.887	2.806	3.714	3.642	1.839	251019
1951	1.289	1.367	1.352	35.269	55.622	13.843	8.821	5.945	9.499	13.431	9.312	3.334	419867
1952	1.642	1.445	1.694	53.574	20.955	8.599	4.386	2.471	3.095	3.261	2.324	1.562	275164
1953	1.275	1.423	2.145	32.424	27.792	33.363	78.014	42.642	20.182	12.019	11.772	5.096	709391
1954	3.300	2.660	2.796	40.592	84.193	134.036	82.652	15.818	19.065	22.938	19.835	7.650	1147397
1955	3.349	3.005	3.008	116.473	169.215	61.473	20.872	8.925	3.960	4.424	4.139	2.696	1058627
1956	2.705	1.425	2.479	36.511	178.127	56.060	23.418	9.422	6.705	5.533	6.597	3.573	881322
1957	2.773	3.741	4.277	49.930	86.457	13.426	6.147	3.518	2.734	2.699	2.524	1.945	475670
1958	1.543	1.559	2.174	16.087	6.187	3.115	1.952	1.179	2.028	2.255	2.849	1.378	110830
1959	1.283	.960	2.979	20.643	9.733	6.492	6.930	2.097	2.304	3.796	4.201	3.062	169549
1960	2.146	1.659	2.429	64.055	43.012	21.424	7.311	1.594	.983	1.479	1.596	1.180	390829
1961	1.155	.972	1.793	4.401	4.181	2.079	.838	.314	.480	1.260	1.352	1.249	52794
1962	.942	.711	1.956	26.888	17.855	3.826	1.608	1.360	1.592	1.563	1.881	1.672	162531
1963	.789	.754	3.134	15.467	7.038	4.976	4.120	1.499	1.310	2.054	1.538	1.285	115546
1964	1.433	1.498	2.025	11.828	11.580	3.369	1.498	1.346	1.141	1.959	2.069	1.185	107781
1965	1.077	1.010	1.109	38.533	22.854	28.926	9.423	4.340	3.513	5.349	3.080	2.108	318289
1966	2.533	1.881	2.685	67.529	48.833	17.848	15.862	7.303	3.325	2.299	2.705	2.117	460119
1967	2.073	1.566	2.002	13.400	56.432	13.580	3.623	1.805	.672	1.285	1.568	1.342	263160
1968	1.184	1.356	5.139	20.939	5.017	3.331	2.218	1.805	.684	.530	.594	.633	113881
1969	1.460	1.636	1.624	40.055	10.254	3.067	3.420	3.860	1.416	3.187	2.832	1.676	194985
1970	1.503	1.473	1.873	36.084	52.997	11.598	8.524	2.675	1.148	3.603	6.883	3.206	347194
1971	2.318	1.789	1.759	95.040	27.426	13.489	6.998	3.264	.571	1.767	3.165	3.110	420246
1972	1.342	.575	1.885	95.131	87.075	10.647	3.271	1.105	.812	.780	.525	.271	535486
1973	.244	.669	4.021	10.800	9.165	13.335	10.392	2.410	2.721	2.285	2.715	2.595	161601
1974	2.318	2.090	4.545	93.955	102.183	44.771	5.171	3.044	4.135	4.270	3.366	3.537	719057
1975	2.755	3.370	2.488	65.311	115.401	33.096	10.254	5.819	4.395	5.540	5.689	3.868	680738
1976	3.524	3.374	4.110	143.603	38.653	46.783	27.063	5.882	.985	.926	2.004	2.450	730942
1977	.479	1.957	4.151	18.170	10.572	2.513	2.992	1.639	5.336	5.206	3.228	9.294	172504
1978	1.238	.246	.504	32.506	16.116	4.981	2.924	2.220	2.299	2.539	4.386	1.995	183839
1979	1.254	.807	1.063	71.670	131.800	31.638	8.241	3.146	4.741	.393	1.848	2.719	684859
1980	1.815	.690	1.437	48.159	10.512	3.313	2.675	1.905	2.371	2.519	2.667	1.155	207172
1981	.140	1.204	6.615	12.927	6.348	4.804	3.564	1.839	.973	3.550	4.055	.851	123257
1982	.117	.142	.770	20.437	10.595	3.809	13.558	1.744	.697	1.606	2.239	2.805	154349
1983	1.000	.615	2.613	44.853	58.534	21.373	21.466	9.665	3.111	.386	4.033	1.495	446537
1984	.254	1.424	12.428	29.292	18.260	18.767	11.284	1.594	1.651	2.676	1.976	2.153	267841
1985	.389	.729	1.419	112.832	41.434	15.154	5.074	6.466	3.303	4.415	3.833	2.719	517834
1986	2.464	1.565	5.713	99.312	26.969	9.221	7.156	4.306	.640	4.680	2.202	3.464	439118
1987	1.924	.312	5.479	57.604	10.553	6.968	7.704	2.862	1.737	3.250	4.103	2.022	273777
1988	3.923	3.694	5.551	75.822	61.263	12.273	4.137	2.592	.160	1.863	1.831	2.584	462156
1989	1.808	1.677	1.974	10.353	4.634	4.843	4.226	2.667	2.049	2.075	2.589	1.906	107131
1990	2.293	2.227	2.334	77.553	33.006	12.261	5.319	2.032	1.496	.470	.609	1.805	370220
1991	1.625	1.804	1.969	21.098	8.815	6.348	11.122	1.331	.415	1.003	.569	1.786	152114
1992	3.056	4.068	1.997	42.514	17.060	5.026	2.726	1.458	1.413	2.949	2.799	2.022	228076
1993	1.856	1.075	4.434	9.329	5.900	2.720	25.285	13.142	18.583	6.898	5.170	2.519	256194
1994	3.367	1.775	10.043	29.386	11.963	15.579	33.882	12.133	6.607	3.344	4.135	3.634	358581
1995	2.879	2.358	7.074	214.751	182.214	34.503	17.642	25.323	13.723	8.597	9.906	4.163	1376970
MIN	.117	.142	.504	4.401	4.181	2.079	.838	.314	.160	.386	.525	.271	52794
MAX	3.923	4.068	12.428	214.751	182.214	134.036	82.652	42.642	20.182	22.938	19.835	9.294	1376970
MEAN	1.716	1.563	3.021	47.178	41.075	17.077	11.607	5.208	3.677	3.693	3.655	2.398	373422

Table D-14

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA14 ASIN D14
SHELL RIVER NEAR INGLIS (05MD005)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.340	.280	.310	3.060	2.890	1.980	.850	.510	.540	.790	.910	.420	33864
1942	.400	.370	.510	8.130	4.300	4.220	2.440	1.950	2.070	2.380	1.870	.820	77402
1943	.650	.570	.650	10.250	5.950	5.320	2.860	1.420	1.080	1.330	1.420	.740	84643
1944	.620	.540	.540	1.250	2.550	1.980	1.270	.650	.790	1.080	1.250	.620	34646
1945	.540	.450	.620	3.710	4.840	3.200	2.750	1.300	1.190	1.500	1.470	.710	58731
1946	.570	.510	.760	6.510	3.910	2.180	2.380	.910	.760	1.190	1.560	.820	58002
1947	.680	.570	.620	7.700	10.680	7.790	9.000	2.800	2.580	2.890	2.380	1.420	129622
1948	1.050	.820	.960	11.600	29.600	6.180	11.500	8.380	2.810	2.070	1.550	1.080	205789
1949	.820	.760	.461	5.190	2.970	4.700	2.440	2.340	1.250	1.150	1.280	.710	63202
1950	.590	.480	.590	4.700	9.850	6.620	5.710	3.440	1.290	2.220	1.760	.590	99985
1951	.420	.370	.420	9.210	17.700	4.360	3.730	2.790	5.020	5.660	3.570	1.020	143346
1952	.650	.570	.680	10.300	5.640	3.660	1.920	1.140	1.810	2.010	1.370	.590	79683
1953	.420	.340	.450	6.520	9.020	10.500	19.500	5.280	5.530	4.520	5.350	2.180	183945
1954	1.390	1.100	1.390	6.820	15.000	30.200	14.000	3.230	5.230	6.730	4.270	2.460	241626
1955	1.670	1.330	1.640	16.800	17.500	7.550	4.320	1.430	1.050	1.460	1.670	1.020	151164
1956	.820	.740	1.080	4.780	14.400	6.520	7.130	2.750	2.470	1.950	1.760	1.330	121014
1957	1.350	1.070	.930	9.160	15.100	3.920	2.080	1.400	1.170	1.310	1.360	.886	104803
1958	.419	.369	.748	4.020	2.210	1.580	1.010	.567	1.180	1.580	1.790	.686	42444
1959	.673	.446	1.510	5.480	6.040	4.380	5.250	1.090	1.410	2.680	2.470	1.720	87484
1960	.905	1.030	1.090	10.600	8.630	9.590	2.030	.652	.343	.528	1.020	.563	97010
1961	.728	.541	.503	1.480	1.380	.790	.407	.143	.122	.323	.829	.687	20829
1962	.822	1.020	1.030	2.330	2.450	1.330	.321	.386	.477	.847	.896	.368	32183
1963	.227	.236	.815	5.060	4.740	2.320	1.480	.701	.637	.849	.798	.624	48693
1964	.563	.555	.555	4.940	4.070	1.280	.612	.502	.471	.736	.556	.015	39066
1965	.001	.000	.000	5.690	9.140	6.170	2.060	1.640	1.600	3.190	1.430	.874	83873
1966	.949	.972	1.070	8.710	12.100	7.570	6.200	1.390	.576	.808	.888	.790	110769
1967	.780	.681	.716	1.870	9.180	5.210	1.520	.630	.284	.584	.804	.686	60574
1968	.659	.693	1.380	4.570	2.240	1.260	1.020	1.080	.908	.910	.945	.654	42925
1969	.799	.926	1.050	5.030	3.160	1.620	2.110	2.080	.941	2.210	1.620	.993	59333
1970	.785	.814	.807	7.130	18.700	3.710	2.770	3.560	.624	1.290	6.520	1.770	128084
1971	1.190	1.080	.936	15.400	7.940	4.270	2.780	1.890	.589	1.320	1.460	1.110	104886
1972	1.160	1.060	1.100	11.300	16.000	3.450	2.690	1.000	.655	.891	.916	.578	107685
1973	.292	.277	.758	4.680	2.290	3.300	3.900	1.010	1.690	1.750	1.470	1.220	59597
1974	.871	.796	.902	15.400	23.600	10.200	2.710	1.400	1.830	2.850	1.760	1.120	167187
1975	1.100	1.040	1.100	7.580	17.700	10.400	3.470	1.410	1.800	2.990	2.780	1.160	138478
1976	1.060	1.260	1.110	18.400	7.110	24.700	9.340	1.900	.935	1.010	.823	.499	178431
1977	.364	.497	.523	5.030	3.240	1.660	2.070	1.500	3.400	4.240	2.300	1.350	68905
1978	1.090	.745	1.340	6.380	6.880	3.450	1.570	.598	.818	1.390	1.410	.752	69536
1979	.523	.499	.568	11.800	21.700	11.900	2.090	.752	.902	.835	1.560	.805	142067
1980	.745	.753	.889	8.220	3.290	1.020	.832	.967	.886	1.100	1.230	.530	53908
1981	.338	.423	2.970	4.370	2.660	1.950	1.440	.867	.585	1.290	1.330	.504	49337
1982	.217	.371	.373	4.980	3.870	1.880	4.100	2.480	.492	1.200	1.340	.699	58083
1983	.819	.831	.748	7.590	12.200	7.650	6.340	1.930	.714	1.280	1.560	.963	112438
1984	.586	.707	4.640	7.930	7.390	6.470	5.930	.757	.766	2.240	1.200	2.000	107250
1985	1.140	.854	1.030	11.500	6.350	4.550	2.300	4.340	2.500	3.150	1.840	1.400	107708
1986	1.520	1.190	1.960	12.600	10.100	3.550	2.560	1.560	.741	3.120	1.570	1.220	109762
1987	1.070	.785	.981	12.300	3.320	3.060	4.130	1.900	1.000	1.840	2.010	1.510	89023
1988	.692	.720	.709	13.600	27.700	4.330	1.670	.811	.420	.724	.741	.673	139619
1989	.600	.612	.579	3.010	1.780	2.710	2.280	.770	1.220	1.600	2.090	1.190	48454
1990	.847	.976	1.440	11.900	17.600	5.540	2.340	.803	.554	.720	.832	.622	116436
1991	.523	.584	.717	4.150	3.450	3.590	5.770	1.510	.652	.731	1.090	.913	62454
1992	.868	.838	.952	6.790	4.640	2.100	1.070	.645	.996	1.490	1.270	1.020	59635
1993	.879	.450	1.070	3.280	2.350	1.200	7.140	2.880	3.800	2.390	1.750	1.340	75429
1994	1.030	.923	1.670	7.270	2.700	4.160	18.600	8.160	4.030	2.020	1.520	1.160	140900
1995	1.190	.843	1.370	19.800	32.500	9.230	3.470	4.840	2.400	1.740	1.610	1.200	211716
MIN	.001	.000	.000	1.250	1.380	.790	.321	.143	.122	.323	.556	.015	20829
MAX	1.670	1.330	4.640	19.800	32.500	30.200	19.500	8.380	5.530	6.730	6.520	2.460	241626
MEAN	.764	.697	.988	7.779	9.169	5.346	4.023	1.869	1.465	1.832	1.688	.971	96430

Table D-15

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA15 ASIN D15
WHITESAND RIVER ABOVE CONFLUENCE WITH YORKTON CREEK
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	1.684	.343	.221	.000	.000	.000	.000	.000	.000	5857
1942	.000	.000	.081	3.941	.498	1.389	.438	.461	.446	.320	.066	.000	19961
1943	.000	.000	.000	4.085	.821	.593	.252	.185	.110	.096	.070	.000	16220
1944	.000	.000	.000	.185	.137	.108	.015	.000	.000	.000	.000	.000	1167
1945	.000	.000	.000	.348	.191	.138	.071	.000	.012	.032	.000	.000	2082
1946	.000	.000	.060	1.097	.178	.053	.023	.001	.024	.074	.000	.000	3943
1947	.000	.000	.000	3.006	3.074	.632	.430	.054	.047	.063	.000	.000	19252
1948	.000	.000	.000	9.254	8.028	.368	.226	.052	.002	.003	.000	.000	47198
1949	.000	.000	.000	.000	.060	.000	.013	.030	.028	.000	.000	.000	351
1950	.000	.000	.037	2.176	.886	.137	.073	.062	.000	.000	.000	.000	8826
1951	.000	.000	.000	2.275	3.560	.412	.150	.018	.071	.157	.116	.000	17859
1952	.000	.000	.004	3.616	.473	.096	.009	.000	.000	.000	.000	.000	10926
1953	.000	.000	.025	2.223	1.204	2.399	7.448	3.526	1.079	.495	.615	.108	50670
1954	.058	.043	.068	7.241	5.040	17.862	4.898	1.316	1.711	2.154	.955	.295	109121
1955	.124	.108	.096	16.263	25.164	5.796	3.044	1.213	.319	.353	.212	.161	139584
1956	.095	.078	.083	11.533	19.144	4.558	1.965	.456	.215	.235	.317	.000	102145
1957	.000	.000	.000	7.074	4.919	.899	.292	.124	.037	.000	.000	.000	35047
1958	.000	.000	.080	1.346	.311	.054	.000	.000	.000	.000	.000	.000	4678
1959	.000	.000	.000	.688	.052	.031	.114	.000	.000	.009	.000	.000	2332
1960	.000	.000	.046	4.962	1.664	.735	.319	.001	.000	.000	.000	.000	20206
1961	.000	.000	.000	.074	.025	.000	.000	.000	.000	.000	.000	.000	257
1962	.000	.000	.000	2.765	.675	.026	.000	.000	.000	.000	.000	.000	9042
1963	.000	.000	.038	.196	.003	.018	.000	.000	.000	.000	.000	.000	666
1964	.000	.000	.000	.000	.232	.021	.000	.000	.000	.150	.121	.000	1394
1965	.000	.000	.000	2.030	.877	.860	.117	.035	.011	.067	.000	.000	10453
1966	.000	.000	.000	5.474	2.563	.800	.714	.568	.055	.130	.000	.000	27049
1967	.000	.000	.000	1.294	5.027	.486	.011	.002	.003	.243	.030	.000	18851
1968	.000	.000	.193	.580	.064	.037	.000	.000	.053	.000	.000	.000	2426
1969	.000	.000	.000	2.640	.460	.042	.033	.035	.000	.101	.063	.000	8800
1970	.000	.000	.000	3.603	3.659	.671	.611	.028	.000	.303	.115	.000	23700
1971	.000	.000	.031	9.034	1.389	.916	.641	.086	.000	.008	.000	.000	31561
1972	.000	.000	.010	9.103	2.933	.157	.010	.000	.000	.000	.000	.000	31911
1973	.000	.000	.083	.153	.133	.645	.245	.000	.080	.000	.000	.000	3511
1974	.000	.000	.017	7.104	7.899	3.251	.157	.103	.113	.080	.031	.000	49325
1975	.000	.000	.049	7.946	15.484	2.214	.761	.198	.215	.149	.291	.141	72596
1976	.075	.070	.092	17.772	4.089	3.573	3.358	.628	.176	.068	.040	.000	78318
1977	.000	.000	.028	.473	.533	.004	.000	.000	.000	.000	.000	.000	2739
1978	.000	.000	.000	.942	.159	.000	.269	.015	.000	.000	.000	.000	3627
1979	.000	.000	.002	7.452	11.206	1.561	.126	.018	.113	.063	.072	.000	54413
1980	.000	.000	.000	2.808	.731	.075	.000	.000	.000	.007	.000	.000	9448
1981	.000	.000	.086	.065	.040	.278	.126	.008	.000	.190	.274	.106	3089
1982	.040	.030	.012	1.333	.451	.169	.619	.031	.000	.000	.000	.000	7054
1983	.000	.000	.028	4.274	4.201	1.415	2.335	.434	.000	.000	.000	.000	33491
1984	.000	.000	.271	1.230	.727	.365	.102	.000	.000	.046	.000	.000	7204
1985	.000	.000	.026	15.089	3.780	1.251	.385	.107	.049	.073	.051	.000	54317
1986	.000	.000	.740	8.725	2.326	.834	.563	.141	.000	.000	.000	.000	34876
1987	.000	.000	.000	2.356	.624	.105	.256	.000	.000	.000	.000	.000	8735
1988	.000	.180	.182	3.638	3.444	.864	.000	.000	.000	.000	.000	.000	21833
1989	.000	.000	.000	.047	.001	.058	.000	.000	.000	.000	.070	.008	478
1990	.000	.000	.000	7.504	1.913	.003	.000	.000	.000	.000	.052	.030	24795
1991	.000	.000	.000	.499	.080	.000	.000	.000	.000	.000	.021	.020	1615
1992	.000	.000	.000	1.445	1.010	.009	.385	.000	.080	.000	.000	.000	7714
1993	.000	.010	.077	.141	.009	.089	1.918	.171	.139	.034	.000	.000	6896
1994	.000	.000	1.277	2.675	.955	1.247	3.105	.161	.086	.086	.100	.052	25739
1995	.022	.025	.507	29.408	19.221	4.248	.000	.606	1.066	1.260	1.161	.461	152204
MIN	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	257
MAX	.124	.180	1.277	29.408	25.164	17.862	7.448	3.526	1.711	2.154	1.161	.461	152204
MEAN	.008	.010	.079	4.416	3.140	1.141	.666	.198	.115	.128	.088	.025	26319

Table D-16

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA16 ASIN D16
STONY CREEK NEAR KAMSACK (05MD010)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.088	.277	.203	.000	.000	.000	.000	.000	.000	.000	1497
1942	.000	.000	.169	.323	.243	.100	.125	.086	.000	.000	.000	.000	2765
1943	.000	.000	.090	.630	.512	.424	.103	.000	.000	.000	.000	.000	4620
1944	.000	.000	.067	.447	.182	.131	.098	.000	.000	.000	.000	.000	2428
1945	.000	.000	.153	.597	.521	.226	.282	.128	.000	.000	.000	.000	5037
1946	.000	.000	.184	1.282	.350	.141	.269	.000	.000	.000	.000	.000	5839
1947	.000	.000	.081	1.196	1.483	1.018	1.407	.247	.000	.000	.000	.000	14358
1948	.000	.000	.091	1.078	3.582	.471	.298	.247	.000	.000	.000	.000	15312
1949	.000	.000	.000	.000	.154	.264	.160	.127	.000	.000	.000	.000	1865
1950	.000	.000	.117	.507	.626	.201	.130	.000	.000	.000	.000	.000	4173
1951	.000	.000	.071	.437	.498	.253	.000	.000	.000	.000	.000	.000	3312
1952	.000	.000	.000	.482	.263	.123	.000	.000	.000	.000	.000	.000	2273
1953	.000	.000	.137	.762	.192	.138	.000	.000	.000	.000	.000	.000	3214
1954	.000	.000	.000	.071	.397	.000	2.647	.275	.000	.000	.000	.000	9074
1955	.000	.000	.070	.377	1.483	1.807	.333	.235	.000	.000	.000	.000	11342
1956	.000	.000	.000	.000	3.165	1.651	.471	.000	.000	.000	.000	.000	14018
1957	.000	.000	.000	.000	2.240	.325	.196	.000	.000	.000	.000	.000	7367
1958	.000	.000	.096	.286	.121	.000	.000	.000	.000	.000	.000	.000	1323
1959	.000	.000	.000	.824	.181	.000	.000	.000	.000	.000	.000	.000	2621
1960	.000	.000	.000	.000	1.299	.202	.000	.000	.000	.000	.000	.000	4003
1961	.000	.000	.094	.182	.182	.080	.000	.000	.000	.000	.000	.000	1418
1962	.000	.000	.081	.376	.728	.112	.000	.000	.000	.000	.000	.000	3432
1963	.000	.000	.120	.335	.067	.132	.185	.000	.000	.000	.000	.000	2207
1964	.000	.000	.127	.137	.170	.108	.000	.000	.000	.000	.000	.000	1431
1965	.000	.000	.000	.539	.364	.250	.141	.116	.000	.000	.000	.000	3708
1966	.000	.000	.071	.247	1.106	.090	.290	.000	.000	.000	.000	.000	4803
1967	.000	.000	.000	.000	.385	.208	.115	.000	.000	.000	.000	.000	1878
1968	.000	.000	.178	.673	.124	.000	.000	.000	.000	.000	.000	.000	2553
1969	.000	.000	.038	.661	.176	.000	.000	.000	.000	.000	.000	.000	2286
1970	.000	.000	.087	.620	.499	.134	.174	.000	.000	.000	.000	.000	3990
1971	.000	.000	.000	2.050	.094	.424	.066	.016	.007	.021	.000	.000	6958
1972	.000	.000	.014	3.130	.480	.054	.012	.000	.000	.006	.000	.000	9624
1973	.000	.000	.106	.101	.058	.148	.029	.001	.017	.011	.000	.000	1239
1974	.000	.000	.000	2.400	.868	.039	.000	.000	.001	.003	.000	.000	8657
1975	.000	.000	.000	1.960	.626	.194	.010	.000	.001	.002	.000	.000	7295
1976	.000	.000	.000	3.180	.131	.086	.006	.000	.000	.000	.000	.000	8832
1977	.000	.000	.009	.105	.018	.001	.000	.000	.000	.000	.000	.000	347
1978	.000	.000	.020	.430	.041	.009	.001	.001	.001	.016	.000	.000	1352
1979	.000	.000	.000	2.730	.946	.019	.001	.000	.000	.000	.000	.000	9662
1980	.000	.000	.000	.784	.001	.000	.000	.000	.000	.000	.000	.000	2035
1981	.000	.000	.054	.034	.028	.042	.024	.005	.000	.004	.000	.000	505
1982	.000	.000	.013	.711	.006	.008	.349	.006	.003	.024	.000	.000	2937
1983	.000	.000	.010	2.340	.770	.210	.312	.034	.003	.004	.000	.000	9644
1984	.000	.000	.545	.478	.135	.092	.005	.009	.003	.008	.000	.000	3365
1985	.000	.000	.012	3.870	.308	.117	.048	.002	.019	.034	.000	.000	11466
1986	.000	.000	.404	2.010	.303	.005	.064	.013	.001	.086	.018	.000	7602
1987	.000	.000	.122	1.400	.019	.101	.045	.003	.002	.012	.000	.000	4434
1988	.000	.008	.111	1.980	.660	.017	.001	.003	.002	.002	.000	.000	7283
1989	.000	.000	.064	.234	.009	.013	.018	.003	.002	.004	.001	.000	910
1990	.000	.000	.020	2.930	.256	.054	.062	.026	.004	.003	.000	.000	8728
1991	.000	.000	.009	1.150	.449	.068	.424	.030	.010	.045	.000	.000	5746
1992	.000	.000	.041	1.740	.424	.129	.012	.001	.001	.016	.000	.000	6170
1993	.000	.002	.044	.072	.021	.202	.395	.143	.110	.083	.000	.000	2838
1994	.000	.000	.230	.513	.038	.216	.262	.026	.052	.035	.000	.000	3607
1995	.000	.000	.101	6.830	3.220	.248	.041	.035	.001	.009	.000	.000	27471
MIN	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	347
MAX	.000	.008	.545	6.830	3.582	1.807	2.647	.275	.110	.086	.018	.000	27471
MEAN	.000	.000	.075	1.027	.571	.202	.175	.033	.004	.008	.000	.000	5506

Table D-17

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA17 ASIN D17
CUSSED CREEK AT THE MOUTH
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	1.375	.280	.180	.000	.000	.000	.000	.000	.000	4781
1942	.000	.003	.066	3.217	.407	1.134	.358	.376	.364	.261	.054	.000	16294
1943	.000	.000	.000	3.335	.670	.484	.206	.151	.090	.079	.057	.000	13240
1944	.000	.000	.000	.151	.112	.088	.012	.000	.000	.000	.000	.000	952
1945	.000	.000	.000	.284	.156	.113	.058	.000	.010	.026	.000	.000	1699
1946	.000	.000	.049	.895	.146	.043	.019	.001	.019	.060	.000	.000	3219
1947	.000	.000	.000	2.453	2.510	.516	.351	.044	.038	.052	.000	.000	15715
1948	.000	.000	.000	7.554	6.553	.300	.185	.042	.001	.002	.000	.000	38527
1949	.000	.000	.000	.000	.049	.000	.011	.025	.023	.000	.000	.000	287
1950	.000	.000	.030	1.776	.723	.112	.060	.051	.000	.000	.000	.009	7205
1951	.000	.000	.000	1.857	2.906	.336	.123	.015	.058	.128	.095	.000	14578
1952	.000	.000	.004	2.952	.386	.078	.008	.000	.000	.000	.000	.000	8918
1953	.000	.000	.020	1.815	.983	1.959	6.079	2.878	.881	.404	.502	.088	41361
1954	.047	.035	.055	5.911	4.114	14.581	3.998	1.074	1.397	1.759	.779	.241	89073
1955	.101	.088	.079	13.275	20.541	4.731	2.485	.990	.260	.289	.173	.131	113940
1956	.077	.064	.068	9.414	15.627	3.721	1.604	.372	.176	.192	.259	.000	83378
1957	.000	.000	.000	5.774	4.015	.734	.238	.101	.030	.000	.000	.000	28608
1958	.000	.000	.066	1.099	.254	.044	.000	.000	.000	.000	.000	.000	3819
1959	.000	.000	.000	.562	.042	.025	.093	.000	.000	.007	.000	.000	1904
1960	.000	.000	.037	4.051	1.358	.600	.261	.001	.000	.000	.000	.000	16494
1961	.000	.000	.000	.060	.020	.000	.000	.000	.000	.000	.000	.000	210
1962	.000	.000	.000	2.257	.551	.021	.000	.000	.000	.000	.000	.000	7381
1963	.000	.000	.031	.160	.003	.015	.000	.000	.000	.000	.000	.000	543
1964	.000	.000	.000	.000	.190	.017	.000	.000	.000	.123	.099	.000	1138
1965	.000	.000	.000	1.657	.716	.702	.095	.028	.009	.055	.000	.000	8533
1966	.000	.000	.000	4.468	2.092	.653	.583	.463	.045	.106	.000	.000	22080
1967	.000	.000	.000	1.057	4.103	.397	.009	.002	.003	.199	.024	.000	15388
1968	.000	.000	.158	.474	.052	.030	.000	.000	.043	.000	.000	.000	1961
1969	.000	.000	.000	2.155	.376	.034	.027	.028	.000	.082	.052	.000	7184
1970	.000	.000	.000	2.941	2.987	.548	.498	.023	.000	.247	.094	.000	19345
1971	.000	.000	.025	7.375	1.134	.748	.523	.070	.000	.007	.000	.000	25763
1972	.000	.000	.008	7.431	2.394	.128	.008	.000	.000	.000	.000	.000	26048
1973	.000	.000	.067	.125	.108	.526	.200	.000	.066	.000	.000	.000	2866
1974	.000	.000	.014	5.799	6.448	2.654	.128	.084	.092	.065	.025	.000	40263
1975	.000	.000	.040	6.486	12.640	1.808	.621	.161	.176	.121	.237	.115	59258
1976	.061	.057	.075	14.507	3.338	2.917	2.741	.512	.144	.055	.033	.000	63929
1977	.000	.000	.023	.386	.435	.003	.000	.000	.000	.000	.000	.000	2236
1978	.000	.000	.000	.769	.130	.000	.219	.013	.000	.000	.000	.000	2961
1979	.000	.000	.002	6.083	9.147	1.274	.102	.014	.092	.051	.059	.000	44416
1980	.000	.000	.000	2.292	.597	.061	.000	.000	.000	.006	.000	.000	7712
1981	.000	.000	.071	.053	.033	.227	.103	.006	.000	.155	.224	.087	2521
1982	.032	.025	.010	1.088	.369	.138	.505	.025	.000	.000	.000	.000	5758
1983	.000	.000	.023	3.489	3.429	1.155	1.906	.355	.000	.000	.000	.000	27338
1984	.000	.000	.221	1.004	.593	.298	.084	.000	.000	.038	.000	.000	5881
1985	.000	.000	.021	12.317	3.085	1.021	.314	.087	.040	.060	.041	.000	44338
1986	.000	.000	.604	7.122	1.899	.681	.460	.115	.000	.000	.000	.000	28469
1987	.000	.000	.000	1.923	.509	.086	.209	.000	.000	.000	.000	.000	7130
1988	.000	.147	.149	2.969	2.812	.706	.000	.000	.000	.000	.000	.000	17822
1989	.000	.000	.000	.039	.001	.047	.000	.000	.000	.000	.057	.006	390
1990	.000	.000	.000	6.125	1.562	.002	.000	.000	.000	.000	.042	.025	20240
1991	.000	.000	.000	.407	.066	.000	.000	.000	.000	.000	.017	.016	1318
1992	.000	.000	.000	1.179	.825	.007	.314	.000	.065	.000	.000	.000	6297
1993	.000	.008	.062	.115	.007	.073	1.565	.139	.114	.028	.000	.000	5629
1994	.000	.000	1.042	2.183	.779	1.018	2.534	.131	.071	.070	.081	.042	21011
1995	.018	.020	.414	24.005	15.690	3.468	.000	.495	.870	1.028	.948	.376	124241
MIN	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000	.000	.000	210
MAX	.101	.147	1.042	24.005	20.541	14.581	6.079	2.878	1.397	1.759	.948	.376	124241
MEAN	.006	.008	.064	3.604	2.563	.932	.544	.161	.094	.105	.072	.021	21484

Table D-18

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA18 ASIN D18
YORKTON CREEK NEAR EBENEZER (05MB001)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.920	.020	.000	.000	.000	.000	.000	.000	.000	2438
1942	.000	.000	.000	3.080	.250	.020	.000	.240	.000	.000	.000	.000	5348
1943	.000	.000	.000	3.000	.320	.170	.040	.010	.000	.000	.000	.000	9208
1944	.000	.000	.000	.690	.010	.020	.000	.000	.000	.000	.000	.000	1867
1945	.000	.000	.670	.460	.010	.000	.080	.000	.000	.000	.000	.000	3228
1946	.000	.000	1.350	.200	.010	.000	.000	.000	.000	.000	.000	.000	4161
1947	.000	.000	.000	5.110	1.130	.150	.070	.000	.000	.000	.000	.000	16848
1948	.000	.000	.000	5.680	5.230	.080	.200	.010	.000	.000	.000	.000	29500
1949	.000	.000	.000	2.260	.020	.890	.050	.000	.000	.000	.000	.000	8352
1950	.000	.000	.000	3.170	.110	.010	.020	.000	.000	.000	.000	.000	8591
1951	.000	.000	.000	3.600	.540	.030	.030	.020	.020	.030	.000	.000	11121
1952	.000	.000	.040	1.300	.010	.010	.000	.000	.000	.000	.000	.000	3529
1953	.000	.000	.000	3.010	.130	1.290	2.980	.740	.370	.310	.000	.000	23247
1954	.000	.000	.000	2.160	2.080	6.960	6.110	2.670	2.500	2.720	2.100	.000	71935
1955	.000	.000	.000	12.580	16.080	7.120	3.620	1.190	.140	.160	.000	.000	107806
1956	.000	.000	.000	10.080	20.080	7.000	2.190	.870	.880	.270	.000	.000	109254
1957	.000	.000	.000	6.550	2.660	.390	.180	.120	.100	.000	.000	.000	26176
1958	.000	.000	.060	.110	.000	.000	.000	.000	.000	.000	.000	.000	446
1959	.000	.000	.750	.300	.010	.010	.020	.000	.010	.030	.000	.000	2999
1960	.000	.000	.000	8.160	.120	.060	.000	.000	.000	.000	.000	.000	21628
1961	.000	.000	.000	.010	.000	.000	.000	.000	.000	.000	.000	.000	26
1962	.000	.000	.000	1.560	.150	.070	.000	.000	.000	.000	.000	.000	4627
1963	.000	.000	.170	.120	.030	.020	.030	.010	.020	.010	.000	.000	1084
1964	.000	.000	.000	.990	.040	.000	.000	.010	.000	.000	.000	.000	2700
1965	.000	.000	.000	3.120	.230	.090	.040	.040	.040	.030	.000	.000	9335
1966	.000	.000	.000	5.070	.520	.060	.040	.020	.010	.020	.000	.000	14930
1967	.000	.000	.000	.760	.610	.010	.000	.000	.000	.020	.000	.000	3683
1968	.000	.000	.130	.570	.060	.050	.040	.020	.030	.020	.000	.000	2408
1969	.000	.000	.000	2.860	.100	.020	.050	.050	.030	.050	.000	.000	8212
1970	.000	.000	.000	2.120	.630	.030	.220	.010	.010	.050	.000	.000	8036
1971	.000	.000	.000	3.490	.160	.360	.220	.010	.000	.020	.000	.000	11077
1972	.000	.000	.150	6.630	.310	.050	.020	.010	.010	.010	.000	.000	18680
1973	.000	.000	.180	.070	.010	.210	.140	.430	.150	.050	.000	.000	3284
1974	.000	.000	.020	8.280	3.030	.460	.360	.340	.250	.150	.000	.000	33748
1975	.000	.000	.000	5.820	5.390	2.960	1.390	.680	.500	.390	.000	.000	45079
1976	.000	.000	.090	11.170	3.390	2.890	1.360	.390	.170	.050	.000	.000	51026
1977	.000	.000	.020	.610	.290	.100	.020	.020	.100	.050	.000	.000	3171
1978	.000	.000	.020	1.160	.140	.050	.010	.030	.070	.060	.000	.000	4014
1979	.000	.000	.000	5.170	2.240	.070	.550	.340	.240	.180	.000	.000	23070
1980	.000	.000	.020	5.570	.290	.120	.090	.140	.050	.020	.000	.000	16378
1981	.000	.000	.060	.040	.080	.210	.390	.410	.130	.200	.000	.000	4038
1982	.000	.000	.030	.960	.090	.040	.360	.080	.130	.110	.000	.000	4723
1983	.000	.000	.010	3.360	.120	.000	1.260	.090	.040	.100	.000	.000	13045
1984	.000	.000	.650	.390	.290	.140	.020	.030	.060	.100	.000	.000	4449
1985	.000	.000	.000	1.910	2.110	.690	.030	.020	.030	.020	.000	.000	12656
1986	.000	.000	.000	1.110	.430	.120	.070	.030	.020	.020	.000	.000	4713
1987	.000	.000	.810	.620	.050	.120	.200	.120	.040	.080	.000	.000	5397
1988	.000	.030	.150	1.170	.470	.020	.020	.080	.020	.020	.000	.000	5194
1989	.000	.000	.010	.280	.100	.160	.130	.020	.040	.070	.000	.000	2128
1990	.000	.000	.010	3.650	.270	.070	.030	.020	.020	.010	.000	.000	10605
1991	.000	.000	.020	.980	.220	.110	.130	.110	.030	.030	.000	.000	4269
1992	.000	.000	.120	2.250	.480	.040	.020	.120	.200	.070	.000	.000	8624
1993	.000	.020	.220	.150	.170	.120	.000	.070	.150	.120	.000	.000	2690
1994	.000	.000	.000	.000	.270	.000	.000	.130	.170	.120	.000	.000	1833
1995	.000	.000	.000	8.010	7.000	3.020	2.200	1.400	.490	.890	.180	.130	61449
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	26
MAX	.000	.030	1.350	12.580	20.080	7.120	6.110	2.670	2.500	2.720	2.100	.130	109254
MEAN	.000	.001	.105	2.954	1.429	.667	.455	.203	.132	.121	.041	.002	16037

Table D-19

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA19 ASIN D19
CONJURING CREEK NEAR RUSSELL (05ME005)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.130	.095	.000	.000	.000	.000	.000	.000	.000	591
1942	.000	.000	.079	.152	.114	.000	.000	.000	.000	.000	.000	.000	911
1943	.000	.000	.042	.296	.241	.199	.000	.000	.000	.000	.000	.000	2041
1944	.000	.000	.000	.210	.086	.000	.000	.000	.000	.000	.000	.000	775
1945	.000	.000	.072	.281	.245	.106	.133	.000	.000	.000	.000	.000	2208
1946	.000	.000	.086	.602	.165	.066	.126	.000	.000	.000	.000	.000	2741
1947	.000	.000	.038	.562	.697	.478	.661	.116	.000	.000	.000	.000	6745
1948	.000	.000	.043	.506	1.682	.221	.000	.000	.000	.000	.000	.000	6505
1949	.000	.000	.000	.000	.072	.124	.000	.000	.000	.000	.000	.000	514
1950	.000	.000	.055	.238	.294	.095	.000	.000	.000	.000	.000	.000	1798
1951	.000	.000	.000	.205	.234	.119	.000	.000	.000	.000	.000	.000	1467
1952	.000	.000	.000	.226	.124	.000	.000	.000	.000	.000	.000	.000	918
1953	.000	.000	.064	.358	.090	.000	.000	.258	.081	.000	.000	.000	2241
1954	.000	.000	.000	.033	.187	.000	1.243	.129	.000	.000	.000	.000	4261
1955	.000	.000	.033	.177	.697	.849	.157	.000	.000	.000	.000	.000	5035
1956	.000	.000	.000	.000	1.486	.776	.221	.000	.000	.000	.000	.000	6583
1957	.000	.000	.000	.000	1.052	.153	.000	.000	.000	.000	.000	.000	3214
1958	.000	.000	.045	.134	.000	.000	.000	.000	.000	.000	.000	.000	468
1959	.000	.000	.049	.051	.002	.084	.016	.000	.000	.000	.000	.000	529
1960	.000	.000	.000	1.060	.170	.107	.000	.000	.000	.000	.000	.000	3480
1961	.000	.000	.002	.001	.000	.000	.000	.000	.000	.000	.000	.000	8
1962	.000	.000	.000	.361	.069	.000	.000	.000	.000	.000	.000	.000	1121
1963	.000	.000	.193	.057	.000	.000	.000	.000	.000	.000	.000	.000	665
1964	.000	.000	.000	.298	.090	.000	.000	.000	.000	.000	.000	.000	1013
1965	.000	.000	.000	.558	.100	.015	.000	.000	.035	.036	.001	.000	1943
1966	.000	.000	.035	.939	.225	.008	.001	.000	.000	.000	.000	.000	3154
1967	.000	.000	.000	.409	.251	.002	.000	.000	.000	.000	.000	.000	1738
1968	.000	.000	.184	.293	.008	.000	.000	.000	.000	.000	.000	.000	1274
1969	.000	.000	.000	.690	.009	.000	.005	.000	.000	.000	.000	.000	1826
1970	.000	.000	.000	.493	.385	.009	.000	.000	.000	.000	.000	.000	2332
1971	.000	.000	.000	.460	.038	.178	.146	.013	.000	.010	.000	.000	2208
1972	.000	.000	.000	1.190	.204	.000	.000	.000	.000	.000	.000	.000	3631
1973	.000	.012	.055	.005	.000	.026	.000	.006	.165	.160	.034	.000	1217
1974	.000	.000	.000	1.910	.639	.096	.000	.000	.000	.000	.000	.000	6911
1975	.000	.000	.000	.795	.222	.039	.000	.000	.036	.016	.000	.000	2892
1976	.000	.000	.001	1.450	.063	.235	.099	.153	.128	.000	.000	.000	5546
1977	.000	.000	.000	.273	.112	.012	.022	.070	.021	.018	.000	.000	1388
1978	.000	.000	.005	.726	.113	.002	.000	.039	.005	.005	.000	.000	2334
1979	.000	.000	.000	1.390	.841	.039	.000	.000	.000	.000	.000	.000	5957
1980	.000	.000	.000	.175	.001	.000	.000	.000	.000	.000	.000	.000	456
1981	.000	.024	.130	.139	.000	.000	.001	.001	.000	.000	.000	.000	772
1982	.000	.000	.003	.296	.003	.000	.000	.000	.000	.000	.000	.000	783
1983	.000	.000	.000	.804	.130	.016	.217	.002	.000	.000	.000	.000	3060
1984	.000	.013	.061	.048	.009	.004	.000	.000	.000	.000	.000	.000	355
1985	.000	.000	.000	.845	.012	.001	.000	.000	.001	.036	.000	.000	2324
1986	.000	.000	.250	1.310	.207	.046	.041	.002	.000	.000	.000	.000	4854
1987	.000	.000	.000	.994	.003	.000	.009	.002	.001	.003	.000	.000	2625
1988	.000	.000	.006	.745	.345	.000	.000	.000	.000	.000	.000	.000	2871
1989	.000	.000	.000	.089	.000	.000	.000	.000	.000	.000	.000	.000	231
1990	.000	.000	.000	.624	.202	.022	.040	.005	.000	.000	.000	.000	2336
1991	.000	.000	.001	.640	.108	.029	.006	.000	.000	.000	.000	.000	2042
1992	.000	.000	.000	1.230	.246	.017	.001	.003	.004	.011	.000	.000	3942
1993	.000	.000	.028	.128	.011	.005	.075	.099	.125	.041	.000	.000	1349
1994	.000	.011	.075	.367	.044	.154	.331	.047	.214	.025	.000	.000	3330
1995	.000	.000	.000	2.710	.828	.261	.129	.057	.031	.024	.000	.000	10561
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	8
MAX	.000	.024	.250	2.710	1.682	.849	1.243	.258	.214	.160	.034	.000	10561
MEAN	.000	.001	.030	.521	.241	.084	.067	.018	.015	.007	.001	.000	2583

Table D-20

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA20 ASIN D20
WILLOW BROOK AT WILLOWBROOK (05MB005)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.000	.223	.045	.029	.000	.000	.000	.000	.000	.000	774
1942	.000	.000	.011	.522	.066	.184	.058	.000	.000	.000	.000	.000	2192
1943	.000	.000	.000	.541	.109	.079	.000	.000	.000	.000	.000	.000	1899
1944	.000	.000	.000	.025	.018	.014	.000	.000	.000	.000	.000	.000	149
1945	.000	.000	.000	.046	.025	.018	.000	.000	.000	.000	.000	.000	233
1946	.000	.000	.008	.145	.024	.000	.000	.000	.000	.000	.000	.000	462
1947	.000	.000	.000	.396	.408	.000	.000	.000	.000	.000	.000	.000	2124
1948	.000	.000	.000	1.227	1.064	.049	.000	.000	.000	.000	.000	.000	6157
1949	.000	.000	.000	.000	.008	.000	.000	.000	.000	.000	.000	.000	21
1950	.000	.000	.000	.288	.117	.000	.000	.000	.000	.000	.000	.000	1060
1951	.000	.000	.000	.302	.472	.055	.000	.000	.000	.000	.000	.000	2190
1952	.000	.000	.000	.479	.063	.000	.000	.000	.000	.000	.000	.000	1410
1953	.000	.000	.000	.295	.160	.318	.987	.467	.143	.000	.000	.000	6282
1954	.000	.000	.000	.960	.668	2.368	.649	.174	.227	.286	.127	.000	14303
1955	.000	.000	.000	2.156	3.336	.768	.404	.161	.000	.000	.000	.000	18027
1956	.000	.000	.000	1.529	2.538	.604	.260	.000	.000	.000	.000	.000	13023
1957	.000	.000	.000	.938	.652	.119	.000	.000	.000	.000	.000	.000	4486
1958	.000	.000	.000	.178	.041	.000	.000	.000	.000	.000	.000	.000	571
1959	.000	.000	.000	.091	.000	.000	.000	.000	.000	.000	.000	.000	236
1960	.000	.000	.000	.658	.221	.097	.000	.000	.000	.000	.000	.000	2549
1961	.000	.000	.000	.010	.003	.000	.000	.000	.000	.000	.000	.000	34
1962	.000	.000	.000	.367	.069	.000	.000	.000	.000	.000	.000	.000	1190
1963	.000	.000	.000	.026	.000	.000	.000	.000	.000	.000	.000	.000	67
1964	.000	.000	.000	.168	.256	.003	.000	.000	.000	.000	.000	.000	1129
1965	.000	.000	.000	.179	.297	.416	.079	.000	.000	.000	.000	.000	2549
1966	.000	.000	.000	.670	.338	.077	.030	.001	.000	.000	.000	.000	2925
1967	.000	.000	.000	.290	.657	.009	.000	.000	.000	.000	.000	.000	2535
1968	.000	.000	.013	.078	.001	.000	.000	.000	.000	.000	.000	.000	240
1969	.000	.000	.000	.982	.001	.000	.000	.001	.000	.000	.000	.000	2551
1970	.000	.000	.000	.888	1.220	.087	.002	.000	.000	.000	.000	.000	5800
1971	.000	.000	.000	1.170	.047	.077	.032	.000	.000	.000	.000	.000	3444
1972	.000	.000	.000	1.110	.062	.000	.000	.000	.000	.000	.000	.000	3043
1973	.000	.000	.000	.000	.000	.032	.046	.015	.007	.000	.000	.000	264
1974	.000	.000	.000	1.060	1.750	.522	.000	.000	.000	.000	.000	.000	8788
1975	.000	.000	.000	3.420	2.300	.586	.043	.000	.000	.000	.000	.000	16659
1976	.000	.000	.000	3.530	.363	1.460	.211	.001	.000	.000	.000	.000	14474
1977	.000	.000	.000	.000	.006	.000	.000	.000	.000	.000	.000	.000	16
1978	.000	.000	.000	.000	.070	.003	.000	.000	.000	.000	.000	.000	195
1979	.000	.000	.000	.761	.986	.050	.000	.000	.000	.000	.000	.000	4743
1980	.000	.000	.000	.010	.000	.000	.000	.000	.000	.000	.000	.000	26
1981	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1982	.000	.000	.000	.150	.002	.002	.000	.000	.000	.000	.000	.000	399
1983	.000	.000	.000	.352	.254	.409	.433	.006	.000	.000	.000	.000	3829
1984	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1985	.000	.000	.000	1.860	.061	.019	.006	.000	.000	.000	.000	.000	5050
1986	.000	.000	.133	.370	.138	.002	.000	.000	.000	.000	.000	.000	1690
1987	.000	.000	.000	.209	.003	.000	.000	.000	.000	.000	.000	.000	550
1988	.000	.000	.000	.023	.026	.000	.000	.000	.000	.000	.000	.000	129
1989	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1990	.000	.000	.000	.544	.090	.000	.000	.000	.000	.000	.000	.000	1651
1991	.000	.000	.000	.000	.001	.001	.001	.000	.000	.000	.000	.000	8
1992	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
1993	.000	.000	.010	.019	.001	.012	.254	.023	.000	.000	.000	.000	852
1994	.000	.000	.169	.355	.127	.165	.412	.000	.000	.000	.000	.000	3244
1995	.000	.000	.067	3.898	2.548	.563	.000	.000	.000	.000	.000	.000	18567
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0
MAX	.000	.000	.169	3.898	3.336	2.368	.987	.467	.227	.286	.127	.000	18567
MEAN	.000	.000	.007	.609	.395	.167	.071	.015	.007	.005	.002	.000	3360

Table D-22

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA22 ASIN D22
SMITH CREEK NEAR MARCHWELL (05ME007)
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	.000	.000	.059	.184	.125	.002	.014	.016	.038	.000	.000	.000	1183
1942	.000	.000	.113	.215	.162	.066	.083	.057	.062	.116	.005	.000	2324
1943	.000	.000	.060	.420	.341	.282	.069	.062	.041	.042	.022	.000	3520
1944	.000	.000	.045	.298	.121	.088	.066	.034	.063	.051	.008	.000	2034
1945	.000	.000	.102	.398	.348	.150	.188	.085	.075	.104	.084	.023	4109
1946	.000	.000	.123	.854	.234	.094	.180	.040	.044	.087	.025	.000	4415
1947	.000	.000	.054	.797	.989	.679	.938	.165	.173	.153	.074	.000	10624
1948	.000	.000	.061	.719	2.388	.314	.199	.165	.060	.034	.000	.000	10458
1949	.000	.000	.044	.000	.103	.176	.107	.084	.048	.061	.000	.000	1649
1950	.000	.000	.078	.338	.418	.134	.087	.069	.055	.068	.049	.000	3421
1951	.000	.000	.048	.291	.332	.169	.118	.112	.072	.000	.000	.000	3013
1952	.000	.000	.052	.321	.176	.082	.071	.058	.062	.058	.025	.000	2382
1953	.000	.000	.092	.508	.128	.092	.000	.366	.114	.134	.116	.034	4171
1954	.000	.000	.000	.048	.265	.000	1.765	.183	.097	.156	.058	.000	6871
1955	.000	.000	.047	.251	.989	1.205	.222	.157	.033	.039	.000	.000	7754
1956	.000	.000	.000	.000	2.110	1.101	.314	.207	.112	.106	.000	.000	10475
1957	.000	.000	.173	.000	1.493	.216	.131	.059	.025	.072	.054	.000	5929
1958	.000	.000	.064	.191	.081	.047	.048	.033	.047	.033	.000	.000	1432
1959	.000	.000	.019	.549	.121	.095	.063	.048	.039	.028	.000	.000	2518
1960	.000	.000	.000	.000	.866	.135	.091	.044	.034	.053	.023	.000	3321
1961	.000	.000	.063	.121	.121	.053	.024	.010	.021	.055	.030	.000	1314
1962	.000	.000	.054	.250	.485	.074	.060	.056	.061	.039	.000	.000	2857
1963	.000	.000	.080	.223	.045	.088	.123	.041	.039	.068	.041	.000	1970
1964	.000	.000	.085	.091	.113	.072	.033	.028	.000	.029	.000	.000	1194
1965	.000	.000	.055	.359	.242	.167	.094	.077	.027	.000	.000	.000	2687
1966	.000	.000	.047	.165	.737	.060	.193	.058	.056	.052	.000	.000	3640
1967	.000	.000	.000	.000	.257	.139	.077	.047	.010	.008	.000	.000	1428
1968	.000	.000	.118	.449	.083	.070	.041	.013	.000	.000	.000	.000	2028
1969	.000	.000	.025	.441	.117	.004	.033	.063	.013	.016	.000	.000	1867
1970	.000	.000	.058	.414	.333	.089	.116	.000	.021	.078	.000	.000	2925
1971	.000	.000	.031	.596	.071	.163	.059	.000	.000	.000	.000	.000	2399
1972	.000	.000	.001	1.080	.626	.191	.000	.000	.000	.000	.000	.000	4974
1973	.000	.017	.151	.046	.076	.093	.000	.014	.039	.015	.000	.000	1188
1974	.000	.055	.194	1.759	.498	.229	.007	.025	.033	.000	.000	.000	7311
1975	.000	.000	.000	.573	.312	.020	.000	.000	.004	.013	.000	.000	2418
1976	.000	.000	.000	2.420	.234	.043	.002	.000	.000	.000	.000	.000	7016
1977	.000	.000	.010	.017	.017	.000	.023	.014	.002	.002	.000	.000	226
1978	.000	.000	.047	.346	.028	.000	.000	.005	.001	.002	.000	.000	1119
1979	.000	.000	.000	1.890	1.460	.040	.000	.000	.000	.000	.000	.000	8913
1980	.000	.000	.000	.375	.002	.000	.000	.000	.000	.000	.000	.000	977
1981	.000	.032	.023	.001	.000	.000	.000	.000	.000	.000	.000	.000	142
1982	.000	.000	.013	.081	.018	.000	.000	.000	.000	.000	.000	.000	293
1983	.000	.000	.000	.767	.241	.008	.004	.000	.000	.000	.000	.000	2065
1984	.000	.019	.094	.041	.003	.000	.000	.000	.000	.000	.000	.000	414
1985	.000	.000	.001	2.410	.129	.001	.000	.000	.002	.003	.000	.000	6611
1986	.000	.000	.519	1.320	.043	.002	.002	.015	.000	.001	.000	.000	4980
1987	.000	.000	.004	1.710	.030	.003	.000	.000	.000	.000	.000	.000	4531
1988	.000	.000	.008	.697	.182	.001	.000	.000	.000	.000	.000	.000	2318
1989	.000	.000	.001	.157	.000	.000	.000	.000	.000	.000	.000	.000	410
1990	.000	.000	.000	2.740	.297	.028	.026	.000	.000	.000	.000	.000	8040
1991	.000	.000	.001	1.220	.116	.011	.086	.028	.000	.000	.000	.000	3809
1992	.000	.000	.000	2.180	.406	.102	.098	.021	.002	.004	.000	.000	7337
1993	.000	.000	.013	.103	.004	.001	.029	.007	.010	.010	.000	.000	464
1994	.000	.000	.154	.155	.017	.011	.033	.009	.023	.007	.000	.000	1079
1995	.000	.000	.000	7.150	3.360	.087	.006	.071	.040	.038	.029	.000	28245
MIN	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	142
MAX	.000	.055	.519	7.150	3.360	1.205	1.765	.366	.173	.156	.116	.034	28245
MEAN	.000	.002	.056	.704	.409	.127	.108	.048	.031	.033	.012	.001	4025

Table D-23

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA23 ASIN D23
ASSINIBOINE RIVER ABOVE JUNCTION WITH QU'APPELLE RIVER
(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	1.780	1.937	2.194	21.056	9.029	3.364	1.284	1.012	1.716	.161	1.707	1.646	122669
1942	1.596	1.719	4.340	46.228	12.751	14.688	7.643	7.113	6.672	7.877	2.419	1.747	300975
1943	2.133	1.932	2.568	62.434	25.082	19.365	8.926	4.472	3.015	3.199	2.505	2.331	361472
1944	1.840	1.892	1.993	12.855	7.570	5.669	3.791	1.848	2.890	2.847	1.894	2.228	124393
1945	1.696	1.961	4.076	22.155	19.215	10.041	9.653	4.241	3.829	5.291	4.457	1.549	232135
1946	1.986	1.926	5.250	45.823	14.016	6.149	8.343	2.458	2.363	4.276	8.852	2.458	272328
1947	1.781	1.939	2.311	54.187	58.801	33.139	41.672	8.682	8.770	8.747	5.639	4.109	606138
1948	2.920	2.471	2.970	55.353	174.865	21.391	20.111	14.483	4.945	3.568	4.064	2.391	821212
1949	2.791	1.821	1.880	24.942	7.790	15.228	7.156	5.454	2.885	3.235	4.041	1.815	207153
1950	2.128	2.045	3.132	29.409	32.040	13.068	9.402	7.849	3.579	4.659	4.329	2.605	301111
1951	1.841	2.066	2.015	38.986	59.855	15.999	10.465	7.509	10.504	13.321	11.336	4.947	471845
1952	2.353	2.077	2.424	57.673	23.194	9.746	5.374	3.280	3.966	4.070	2.673	2.225	312125
1953	1.907	2.227	3.314	38.903	29.426	34.645	73.968	47.313	21.641	13.883	13.391	6.967	760310
1954	4.588	3.734	3.618	41.200	87.572	120.709	105.174	18.160	20.414	25.115	26.220	10.466	1231742
1955	4.115	3.852	3.603	119.679	181.831	76.846	23.707	11.109	4.414	4.964	5.120	3.279	1166437
1956	3.791	1.603	3.221	23.170	205.051	70.108	27.421	12.305	8.269	7.005	9.014	4.616	996107
1957	3.577	5.624	6.694	48.487	105.514	16.187	7.968	4.334	3.083	3.704	3.278	2.530	557498
1958	2.323	2.277	2.996	18.519	7.316	3.771	2.615	1.635	2.678	2.721	3.401	1.884	136595
1959	1.729	1.342	3.161	28.212	11.417	7.683	7.786	2.772	2.844	4.188	5.177	3.988	210930
1960	3.014	1.996	3.410	61.038	54.799	23.121	8.574	2.206	1.453	2.222	1.915	1.491	434670
1961	1.358	1.254	2.665	6.092	5.874	2.821	1.177	.447	.767	2.024	1.776	1.705	73574
1962	1.033	.415	2.705	29.774	24.505	4.862	2.448	2.148	2.446	2.105	2.619	2.741	204841
1963	1.245	1.174	3.924	18.481	7.663	6.203	5.838	2.075	1.858	2.999	2.116	1.798	145531
1964	2.118	2.243	3.206	12.599	13.005	4.374	1.957	1.737	1.031	2.367	2.716	1.912	129773
1965	1.776	1.678	1.875	42.604	26.066	31.225	10.729	5.414	3.829	4.115	3.103	2.590	354183
1966	3.361	2.309	3.283	68.252	58.736	18.675	18.553	8.107	4.100	3.018	3.504	2.602	512179
1967	2.711	1.958	2.832	11.781	59.588	15.509	4.690	2.461	.811	1.393	2.050	1.719	284821
1968	1.485	1.747	6.481	26.705	6.157	4.307	2.795	1.983	.005	.022	.103	.465	136965
1969	1.890	2.147	1.973	45.046	11.876	3.122	3.865	4.743	1.593	3.408	3.519	2.116	223305
1970	2.021	1.943	2.678	41.025	56.990	12.828	10.137	.924	1.440	4.694	5.378	3.740	379404
1971	2.919	2.102	2.191	102.575	28.350	15.461	7.570	2.644	.248	1.544	3.797	3.969	453263
1972	.936	.000	1.897	108.198	95.456	13.303	2.948	.824	.781	.512	.000	.000	591684
1973	.099	.890	6.027	11.436	10.226	14.592	9.424	2.590	2.991	2.220	3.339	3.251	176656
1974	3.206	2.853	7.254	115.281	108.051	47.806	5.263	3.393	4.601	3.789	3.243	4.260	812123
1975	3.436	4.683	3.216	73.444	120.519	35.333	10.137	8.415	5.358	6.481	6.646	5.401	746518
1976	5.186	4.772	6.059	158.638	42.478	46.497	24.427	6.182	.142	.322	2.352	3.500	786243
1977	.188	2.824	7.018	20.144	13.077	2.404	3.446	1.341	6.912	5.612	3.590	15.489	216158
1978	1.105	.000	.000	39.903	17.800	5.394	2.913	3.363	3.551	3.367	6.250	2.527	226044
1979	1.491	.774	1.280	82.381	142.518	36.522	11.940	4.705	7.721	.000	1.712	3.895	778678
1980	2.307	.265	1.593	57.006	12.213	4.716	3.822	2.645	3.577	3.441	3.513	1.389	252442
1981	.000	1.644	8.056	15.784	8.019	5.962	4.271	2.009	1.146	4.325	4.941	.579	149128
1982	.000	.000	.773	24.863	12.691	4.090	17.485	.431	.788	1.723	2.676	4.357	184358
1983	.925	.131	4.045	52.227	67.996	25.942	24.143	13.983	4.961	.000	5.574	1.394	531523
1984	.000	1.668	15.157	34.101	21.325	22.139	13.986	1.938	2.384	2.873	1.941	1.659	313668
1985	.000	.291	1.439	127.776	47.496	18.693	6.009	7.850	3.699	4.951	5.012	3.476	593691
1986	2.915	1.488	5.947	118.161	30.689	10.681	9.075	5.894	.413	5.878	2.371	4.930	519751
1987	2.278	.000	7.983	67.536	12.831	8.821	9.046	3.096	2.131	4.170	5.224	1.709	327099
1988	4.691	4.742	8.273	88.079	66.545	15.650	5.752	3.944	.000	2.774	2.537	3.944	544244
1989	2.646	2.400	3.058	13.728	6.209	5.778	5.174	4.166	2.592	2.410	2.599	2.245	139215
1990	3.245	3.068	2.909	93.510	36.116	16.471	7.390	2.828	2.130	.128	.318	2.633	446811
1991	2.420	2.670	2.931	28.414	11.576	8.192	14.603	.739	.080	1.180	.000	2.314	197335
1992	4.720	6.495	2.668	51.753	20.511	6.479	3.240	1.841	1.521	3.886	3.751	2.602	286592
1993	2.457	1.398	6.525	11.832	7.736	3.300	27.589	14.301	20.087	6.875	6.067	2.396	292200
1994	4.520	1.972	12.601	33.067	14.167	18.786	36.617	14.509	7.929	3.739	5.584	4.990	418316
1995	3.733	3.057	11.023	244.790	203.476	36.839	20.223	29.306	15.972	9.496	10.593	4.025	1559622
MIN	.000	.000	.000	6.092	5.874	2.404	1.177	.431	.000	.000	.000	.000	73574
MAX	5.186	6.495	15.157	244.790	205.051	120.709	105.174	47.313	21.641	25.115	26.220	15.489	1559622
MEAN	2.260	2.067	4.122	53.224	46.467	19.176	13.449	6.204	4.355	4.234	4.399	3.156	429378

Table D-24

PSEUDO-NATURAL FLOW ARRAY AT OUTLET OF ASA24

ASIN D24

ASSINIBOINE RIVER NEAR RUSSELL (05ME001)

(m^3/s)

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN TO DEC CU.DAMS
1941	1.420	1.520	1.720	19.780	8.090	3.350	1.170	.880	1.410	.350	1.500	1.35	111295
1942	1.290	1.370	3.560	44.740	11.630	14.150	6.970	6.650	6.170	6.940	2.380	1.530	281425
1943	1.770	1.590	2.150	59.530	22.720	17.410	8.370	3.970	2.680	2.860	2.330	1.960	333575
1944	1.530	1.550	1.630	10.790	6.730	4.960	3.260	1.570	2.380	2.430	1.830	1.840	106483
1945	1.400	1.580	3.370	19.400	16.810	9.000	8.350	3.550	3.220	4.450	3.780	1.360	200813
1946	1.630	1.570	4.400	39.910	12.400	5.500	7.100	2.130	2.010	3.570	7.270	2.080	234772
1947	1.510	1.600	1.940	48.670	51.960	28.440	35.180	7.540	7.370	7.510	5.040	3.510	528254
1948	2.500	2.090	2.550	50.380	158.340	19.220	18.500	13.150	4.460	3.290	3.590	2.120	743391
1949	2.310	1.550	1.520	25.660	7.080	14.010	6.290	4.770	2.500	2.740	3.510	1.580	192567
1950	1.750	1.660	2.590	27.070	29.150	12.140	8.700	7.290	3.130	4.110	3.930	2.160	273269
1951	1.520	1.660	1.630	36.970	57.560	14.830	9.510	6.600	9.920	13.390	10.160	4.010	442688
1952	1.840	1.710	2.000	55.450	21.980	9.080	4.800	2.810	3.460	3.600	2.470	1.840	291294
1953	1.540	1.760	2.680	35.390	28.540	33.900	76.500	44.780	20.850	12.800	12.450	5.880	732784
1954	3.840	3.110	3.140	40.870	85.740	129.050	92.960	16.890	19.630	23.850	22.510	8.830	1187277
1955	3.670	3.360	3.280	117.940	174.990	68.510	22.170	9.840	4.150	4.650	4.550	2.940	1107330
1956	3.160	1.500	2.790	31.520	190.450	62.490	25.250	10.630	7.360	6.150	7.610	4.010	935586
1957	3.110	4.530	5.290	49.390	95.180	14.690	6.910	3.860	2.880	3.120	2.840	2.190	512378
1958	1.870	1.860	2.550	17.200	6.660	3.390	2.230	1.370	2.300	2.450	3.080	1.590	121954
1959	1.470	1.120	3.090	23.850	10.440	7.050	7.300	2.380	2.530	3.960	4.610	3.450	187259
1960	2.510	1.800	2.840	63.590	48.070	22.210	7.840	1.850	1.180	1.790	1.730	1.310	411783
1961	1.240	1.090	2.160	5.110	4.890	2.390	.980	.370	.600	1.580	1.530	1.440	61506
1962	.980	.600	2.270	28.350	20.690	4.260	1.960	1.690	1.950	1.790	2.190	2.120	181077
1963	.980	.930	3.600	16.770	7.300	5.490	4.840	1.740	1.540	2.450	1.780	1.500	128576
1964	1.720	1.810	2.520	12.360	12.240	3.790	1.690	1.510	1.100	2.130	2.340	1.490	117719
1965	1.370	1.290	1.430	40.630	24.270	29.900	9.970	4.790	3.670	4.910	3.090	2.310	334832
1966	2.880	2.060	2.960	68.490	53.140	18.200	16.990	7.640	3.650	2.600	3.040	2.320	484143
1967	2.340	1.730	2.350	13.050	57.930	14.390	4.070	2.080	.730	1.330	1.770	1.500	273563
1968	1.310	1.520	5.830	23.560	5.500	3.740	2.460	1.880	.430	.340	.410	.570	124664
1969	1.640	1.850	1.770	42.630	10.940	3.090	3.610	4.230	1.490	3.280	3.120	1.860	208132
1970	1.720	1.670	2.210	38.500	54.940	12.120	9.200	2.020	1.270	4.060	6.320	3.430	362711
1971	2.570	1.920	1.940	98.520	27.840	14.440	7.340	3.040	.450	1.690	3.430	3.470	435763
1972	1.190	.290	1.890	101.440	90.730	11.760	3.15	1.000	.800	.680	.290	.110	561458
1973	.190	.770	4.900	11.070	9.610	13.880	10.030	2.490	2.950	2.370	3.000	2.870	168896
1974	2.690	2.410	5.680	104.230	105.090	46.110	5.210	3.190	4.330	4.090	3.320	3.840	762970
1975	3.040	3.920	2.760	69.210	117.650	33.970	10.210	6.790	4.780	5.910	6.090	4.510	709191
1976	4.220	3.960	4.840	151.650	40.270	46.850	26.140	6.090	.750	.700	2.150	2.890	760017
1977	.370	2.320	5.230	19.090	11.590	2.480	3.190	1.580	5.940	5.370	3.380	11.890	190726
1978	1.188	.000	.113	35.944	16.834	5.137	2.920	2.675	2.771	2.853	5.167	2.218	204198
1979	1.353	.795	1.144	77.730	137.250	33.515	9.625	3.729	5.856	.104	1.797	3.212	729054
1980	2.021	.531	1.495	51.813	11.150	3.838	3.104	2.182	2.822	2.864	2.985	1.253	225096
1981	.000	1.404	7.250	14.083	6.973	5.237	3.829	1.903	1.038	3.840	4.426	.749	133375
1982	.000	.000	.781	22.329	11.392	3.914	15.027	1.253	.731	1.650	2.422	3.455	166076
1583	.972	.434	3.149	48.595	62.306	23.097	22.606	11.282	3.803	.000	4.679	1.457	481447
1984	.000	1.535	13.546	31.147	19.414	20.031	12.295	1.723	1.925	2.750	1.963	1.968	285040
1985	.000	.565	1.427	120.460	43.790	16.479	5.424	6.984	3.453	4.640	4.327	3.036	551381
1986	2.653	1.536	6.282	108.010	28.517	9.797	7.901	4.911	.555	5.129	2.273	4.078	475689
1987	2.072	.000	6.418	63.012	11.426	7.663	8.212	2.951	1.885	3.596	4.573	1.905	297905
1988	4.245	4.133	6.578	81.310	63.569	13.537	4.741	3.098	.000	2.204	2.127	3.154	496311
1989	2.159	1.980	2.380	11.770	5.223	5.193	4.581	3.228	2.252	2.200	2.593	2.048	119756
1990	2.692	2.579	2.549	85.628	34.482	13.867	6.135	2.333	1.733	.342	.500	2.152	405673
1991	1.958	2.167	2.330	24.999	9.988	7.063	12.482	1.127	.290	1.069	.310	2.007	172828
1992	3.753	5.085	2.248	48.105	18.759	5.644	2.980	1.616	1.457	3.309	3.198	2.265	257681
1993	2.108	1.210	5.242	10.410	6.596	2.941	26.212	13.642	19.230	6.921	5.546	2.473	271011
1994	3.850	1.865	11.143	31.090	12.826	16.882	35.133	13.057	7.250	3.512	4.742	4.202	384182
1995	3.237	2.651	8.551	232.160	192.790	35.595	18.692	26.893	14.609	8.972	10.194	4.111	1469802
MIN	.000	.000	.113	5.110	4.890	2.390	.980	.370	.000	.000	.290	.110	61506
MAX	4.245	5.085	13.546	232.160	192.790	129.050	92.960	44.780	20.850	23.850	22.510	11.890	1469802
MEAN	1.935	1.768	3.485	50.206	43.499	17.994	12.405	5.622	3.958	3.914	3.968	2.716	398702

Appendix III

Manitoba - Active Surface Water Allocations
Saskatchewan - Active Surface Water Allocations

Manitoba - Licenced and Pending Groundwater Allocations
Saskatchewan - Licenced Groundwater Allocations
Saskatchewan - Applications for Groundwater Use Yet to Receive Approval

Manitoba - Active Surface Water Allocations

License Number	Name	Location	Purpose	Status	Maxium Annual Allocation (dam3)
74-27	Bailey, J. W. & M. E.	SE-01-028-29W	Agricultural	Approved License Issued	0
75-16	Alvin Gustav Freier and Caroline Freier	SE-25-019-29W	Domestic	Approved License Issued	8
92-126	Canamera Foods	-33-020-29W	Industrial	Approved License Issued	74
81-28	C S P Foods Ltd.	-33-020-29W	Industrial	License Replaced	74
81-31	Case, R. W. & P. M.	SE27-27-28W	Irrigation	Approved License Issued	185
62-57	Klimchuk, D. M.	S14-27-28W	Irrigation	Approved License Issued	49
62-18	Trinwood Farms Ltd.	-35-019-29W	Irrigation	Approved License Issued	175
62-12	Clement, Harold F. & Rodney S.	NE-15-020-29W	Irrigation	Approved License Issued	222
89-50	Jean Blouin, Roland Blouin and Damien Blouin	-19-017-28W	Irrigation	Approved License Issued	247
78-4	Gaber, B. D., A. G. & D. A.	SE-10-024-28W	Irrigation	License Renewed	62
80-20	Nerbas, G. A. & K. R.	NW-17-022-29W	Irrigation	License Renewed	308
90-41	Neuhofer, Martin	S34-22-29W	Irrigation	Approved License Issued	12
84-40	Neuhofer, M.	SW34-22-29W	Irrigation	License Renewed	12
87-09	Orsak, P. S.	NE-31-019-28W	Irrigation	Approved License Issued	17
66-08	Manitoba Water Services Board	R/A east of NE8-21-28W	Municipal	Approved License Issued	339
1997-048	Ski Asessippi Limited Partnership	NW-32-022-28W	Other	Approved License Issued	69.06
33	Liske, H., McKenzie, J. W. and Ziprick, A. D.	SE-10-023-28W	Other	Approved License Issued	0
90-138	Ducks Unlimited	NW-11-021-28W	Waterfowl Conservation	Approved License Issued	0
64-16	Ducks Unlimited	NE-30-19-26W	Waterfowl Conservation	License Renewed	554
92-147	Ducks Unlimited	NE-30-19-26W	Waterfowl Conservation	Approved License Issued	920
64-19	Ducks Unlimited	NW-15-19-26W	Waterfowl Conservation	License Renewed	192
79-41	Ducks Unlimited	NW11-21-28W	Waterfowl Conservation	License Renewed	36
77-90	Ducks Unlimited	NE-30-19-26W	Waterfowl Conservation	License Renewed	554
75-20	Ducks Unlimited	NW-15-19-26W	Waterfowl Conservation	Approved License Issued	192
90-10	Ducks Unlimited	SW-17-028-29W	Waterfowl Conservation	Approved License Issued	95

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
NW1/4	25	22	30	1	POPOWICH ALVIN D		SHELLMOUTH	Domestic	1	2	1	Reservoir
SW1/4	07	29	30	1	SCHWARTZ ALLEN H		RUNNYMEDE	Domestic	1	2	1	Reservoir
NE1/4	18	22	31	1	MUND DAVID F P		LANGENBURG	Domestic	1	2	1	Reservoir
NW1/4	29	28	31	1	OSTRIKOFF KUZMA		KAMSACK	Domestic	1	2	1	Reservoir
NE1/4	30	28	31	1	KHADIKEN PETER		KAMSACK	Domestic	1	2	1	Reservoir
NE1/4	06	29	31	1	OKEEFE FRANCIS		KAMSACK	Domestic	1	1	0	Reservoir
NW1/4	08	29	31	1	GLEBOFF PETE W		KAMSACK	Domestic	1	2	1	Reservoir
SW1/4	08	29	31	1	GALYE VERNON M		KAMSACK	Domestic	1	1	0	Reservoir
NW1/4	19	29	31	1	BAYOFF NICK		KAMSACK	Domestic	1	1	0	Reservoir
SE1/4	20	29	31	1	PISTER CARL		COTE	Domestic	1	2	1	Reservoir
SW1/4	20	29	31	1	MAKASAEFF PHILIP E		COTE	Domestic	1	2	1	Reservoir
NE1/4	23	29	31	1	FINNIE WILLIAM		KAMSACK	Domestic	1	1	0	Reservoir
SW1/4	29	29	31	1	WARRINER GORDON C		KAMSACK	Domestic	1	2	1	Reservoir
NW1/4	30	29	31	1	FERGUSON CHARLES		KAMSACK	Domestic	1	1	0	Reservoir
NE1/4	07	30	31	1	DE CLOEDT MEDARD		KAMSACK	Domestic	1	1	0	Reservoir
SE1/4	09	30	31	1	SETTER GORDON		KAMSACK	Domestic	1	1	0	Reservoir
NW1/4	25	21	32	1	VERMEERSCH EDMOND		LANGENBURG	Domestic	2	3	1	Reservoir
SW1/4	06	27	32	1	SWERHUN MIKE		STORNOWAY	Domestic	1	1	0	Reservoir
SE1/4	03	28	32	1	MAKORTOFF FREDERICK		KAMSACK	Domestic	1	1	0	Reservoir
SE1/4	20	28	32	1	BUENNEKE FREDERICK		KAMSACK	Domestic	1	2	1	Reservoir
NE1/4	29	28	32	1	MCKAY P G		KAMSACK	Domestic	1	2	1	Reservoir
NW1/4	35	28	32	1	FOWLER EDWARD R		KAMSACK	Domestic	2	2	0	Reservoir
NW1/4	36	28	32	1	JMAEFF PETER P		KAMSACK	Domestic	1	2	1	Reservoir
SW1/4	01	29	32	1	JMAEFF PETER W		KAMSACK	Domestic	1	2	1	Reservoir
NW1/4	10	29	32	1	ACHTEMICHUK MIKE J		KAMSACK	Domestic	1	2	1	Reservoir
NE1/4	18	29	32	1	MACLEAN IAIN C		KAMSACK	Domestic	1	3	2	Reservoir
NW1/4	25	29	32	1	BROWN MILES H		KAMSACK	Domestic	1	1	0	Reservoir
SE1/4	36	29	32	1	HUDYE JOSEPH		KAMSACK	Domestic	1	2	1	Reservoir
NW1/4	02	30	32	1	KONKIN JOHN D		KAMSACK	Domestic	1	1	0	Reservoir
SE1/4	10	30	32	1	WASYLKOUSKI LILLY		KAMSACK	Domestic	2	2	0	Watercourse
SW1/4	18	30	32	1	HORKOFF PETER P		KAMSACK	Domestic	1	2	1	Reservoir
SE1/4	13	29	33	1	GOULDEN WALLACE H		KAMSACK	Domestic	1	2	1	Reservoir
SE1/4	12	30	33	1	REAR EMERSON		KAMSACK	Domestic	1	3	2	Reservoir

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
NE1/4	25	30	33	1	CHERNOFF MIKE P		KAMSACK	Domestic	1	2	1	Reservoir
SW1/4	29	30	01	2	GALISHEFF PETER P		VERIGIN	Domestic	1	2	1	Reservoir
SE1/4	30	30	01	2	MOROZOFF ALEX S		VEREGIN	Domestic	1	3	2	Reservoir
SE1/4	20	31	01	2	ZIETSOFF MIKE G		VEREGIN	Domestic	1	1	0	Reservoir
SW1/4	18	23	02	2	RICHARDSON VIOLET B		SALTCOATS	Domestic	2	2	0	Watercourse
NW1/4	25	30	02	2	BEAR EMMA		VEREGIN	Domestic	2	3	1	Reservoir
SE1/4	28	31	02	2	HARTWIG CLARENCE R		CANORA	Domestic	1	2	1	Reservoir
SE1/4	36	31	02	2	RIEBEN MIKE		MIKADO	Domestic	1	2	1	Reservoir
NW1/4	18	26	03	2	STEWART THOMAS G		YORKTON	Domestic	2	2	0	Reservoir
NE1/4	09	28	03	2	HAIT HENRY		EBENEZER	Domestic	1	5	4	Reservoir
NE1/4	33	27	04	2	YANKE FRED		EBENEZER	Domestic	1	16	15	Reservoir
SW1/4	17	34	04	2	BEATTY JAMES G		STURGIS	Domestic	2	5	3	Reservoir
NW1/4	20	34	04	2	STURGIS		STURGIS	Domestic	0	0	0	Reservoir
NW1/4	25	22	05	2	SZAROZ JOHN JR		MELVILLE	Domestic	1	1	0	Reservoir
NE1/4	02	24	05	2	GULASH VINCENT J		OTTHON	Domestic	1	2	1	Reservoir
NW1/4	15	24	05	2	MOLNAR ANTHONY P		MCKIM	Domestic	1	1	0	Reservoir
SW1/4	15	24	05	2	GULASH EMERICK		MCKIM	Domestic	1	2	1	Reservoir
NE1/4	16	24	05	2	CHILLAC STEVE A		MCKIM	Domestic	1	5	4	Reservoir
SW1/4	26	29	05	2	HUPKA JAMES		CANORA	Domestic	4	5	1	Reservoir
NE1/4	17	23	06	2	WOTHERSPOON DAVID A		MELVILLE	Domestic	1	2	1	Reservoir
NE1/4	25	23	06	2	KOSA JOHN S		MELVILLE	Domestic	1	8	7	Reservoir
NW1/4	36	23	06	2	REID JAMES		MELVILLE	Domestic	1	2	1	Reservoir
SE1/4	36	23	06	2	KOSHA JOHN S		MELVILLE	Domestic	1	2	1	Reservoir
SE1/4	15	24	06	2	CARLSON LESTER		MELVILLE	Domestic	4	4	0	Reservoir
NE1/4	21	24	06	2	CHIZMA THOMAS		WILLOWBROOK	Domestic	2	3	1	Reservoir
SE1/4	27	24	06	2	HARDY JOHN		MELVILLE	Domestic	1	6	5	Reservoir
NE1/4	34	24	06	2	MOLNAR GEORGE		YORKTON	Domestic	1	1	0	Reservoir
NW1/4	32	25	06	2	T H GARRY AND CO		YORKTON	Domestic	1	1	0	Reservoir
NE1/4	14	26	06	2	BORYS WILLIAM		YORKTON	Domestic	1	2	1	Reservoir
NW1/4	18	35	06	2	BOYKO FRED		KETCHEN	Domestic	1	2	1	Reservoir
NE1/4	16	23	07	2	HALYK WILLIAM		BIRMINGHAM	Domestic	1	5	4	Reservoir
NE1/4	22	23	07	2	HALYK VICTOR		BIRMINGHAM	Domestic	1	3	2	Reservoir
NE1/4	29	25	07	2	CHURKO ANDREW		ROCK DELL	Domestic	2	4	2	Reservoir

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
SE1/4	36	28	07	2	MADSEN KELLY		THEODORE	Domestic	5	6	1	Reservoir
SE1/4	30	29	07	2	ANDRUSIAK GEORGE		INSINGER	Domestic	1	2	1	Reservoir
NE1/4	05	27	08	2	FLAMAN ROBERT J		JEDBURGH	Domestic	3	9	6	Reservoir
SE1/4	28	26	08	2	LESSAK GEORGE K		INSINGER	Domestic	1	2	1	Reservoir
NW1/4	17	29	09	2	WUNDER CLIFFORD		SHEHO	Domestic	1	5	4	Reservoir
SE1/4	21	29	09	2	SEBULSKY MIKE		SHEHO	Domestic	4	6	2	Reservoir
NE1/4	31	29	09	2	DUMANSKI M S		SHEHO	Domestic	1	2	1	Reservoir
NW1/4	31	29	09	2	BUDZINSKI MATT		INSINGER	Domestic	1	2	1	Reservoir
NW1/4	22	30	09	2	LUNDAGO GRANT		SHEHO	Domestic	0	0	0	Lake
NW1/4	32	32	09	2	LAPPI JACOB		MARGO	Domestic	1	1	0	Reservoir
SW1/4	12	33	09	2	ENRIGHT FRANK S		INVERMAY	Domestic	1	2	1	Reservoir
NE1/4	30	34	11	2	MACLEAN WILLIAM		KUROKI	Domestic	1	2	1	Reservoir
NE1/4	03	19	30	1	CLARKE HARRIS K		SPY HILL	Irrigation	49	49	0	Watercourse
SE1/4	05	19	30	1	OLSON ALEXANDER E		SPY HILL	Irrigation	161	161	0	Lake
SE1/4	25	19	30	1	MARCHWELL SOUTH CAA		LANGENBURG	Irrigation	0	0	0	Watercourse
SE1/4	11	21	30	1	SCHAPPERT KINGSLEY		UNKNOWN	Irrigation	24	24	0	Dugout
SE1/4	29	21	30	1	REMUS CALVIN		LANGENBURG	Irrigation	5	5	0	Watercourse
SW1/4	15	25	30	1	SHEWCHUK PETER E		MACNUTT	Irrigation	5	5	0	Watercourse
SE1/4	06	28	30	1	BURBACK VERNON		TOGO	Irrigation	6	6	0	Watercourse
SW1/4	06	28	30	1	BURBACK VERNON		TOGO	Irrigation	30	30	0	Watercourse
SW1/4	13	19	31	1	OLSON KENNETH		SPY HILL	Irrigation	2	2	0	Watercourse
SW1/4	24	19	31	1	OLSON ALEXANDER		SPY HILL	Irrigation	22	22	0	
NE1/4	29	21	31	1	WELKE CARL		LANGENBURG	Irrigation	10	10	0	
SE1/4	07	22	31	1	DECOCK JAMES		LANGENBURG	Irrigation	20	30	10	Lake
SE1/4	08	22	31	1	WINDERMERE ENT. LTD		LANGENBURG	Irrigation	15	18	3	Reservoir
SE1/4	04	27	31	1	DUBNYK ALBERT		WROXTON	Irrigation	10	10	0	Lake
NE1/4	18	28	31	1	CHERKAS PAUL		KAMSACK	Irrigation	12	12	0	Watercourse
NE1/4	19	28	31	1	CHERKAS PAUL		KAMSACK	Irrigation	13	13	0	Watercourse
SE1/4	07	30	31	1	MERRETT WILLIAM H		KAMSACK	Irrigation	5	5	0	
NW1/4	15	20	32	1	PETRACEK EMIL J		YARBO	Irrigation	9	9	0	Watercourse
SW1/4	07	21	32	1	NECHVATAL HENRY		CHURCHBRIDGE	Irrigation	0	0	0	Watercourse
NW1/4	10	21	32	1	BRENNER DALE		CHURCHBRIDGE	Irrigation	7	7	0	Watercourse
NW1/4	36	23	32	1	REETZ HERBERT E		CHURCHBRIDGE	Irrigation	0	0	0	

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
SW1/4	35	28	32	1	BURBACK ALEX		KAMSACK	Irrigation	5	5	0	Watercourse
SW1/4	24	29	32	1	MORIARTY GERALD		KAMSACK	Irrigation	7	7	0	Watercourse
NW1/4	32	29	32	1	STYRANKA TOM		KAMSACK	Irrigation	1	1	0	
SW1/4	34	29	32	1	LESANN HENRY		KAMSACK	Irrigation	4	4	0	Watercourse
NE1/4	04	30	32	1	PRODANUK THOMAS		KAMSACK	Irrigation	9	9	0	Watercourse
NE1/4	33	26	01	2	MEHLING BARRY		STORNOWAY	Irrigation	5	5	0	Watercourse
NW1/4	02	27	01	2	WINTONYK LARRY J		YORKTON	Irrigation	27	27	0	Watercourse
NW1/4	21	29	01	2	MANDZUK DEBBIE		VEREGIN	Irrigation	14	53	39	Lake
NE1/4	34	29	01	2	SHUKIN PETER H		VEREGIN	Irrigation	2	2	0	
NW1/4	34	29	01	2	SHUKIN JOHN H		VEREGIN	Irrigation	2	2	0	
SW1/4	15	27	02	2	PROPP RICHARD C		RHEIN	Irrigation	34	34	0	Watercourse
SW1/4	19	28	02	2	FILIPCHUK GLEN		RHEIN	Irrigation	15	15	0	Watercourse
NW1/4	06	29	02	2	MAKOWSKY MICHAEL L		CANORA	Irrigation	0	0	0	Watercourse
NE1/4	07	26	03	2	BLOMMAERT WILFRED		YORKTON	Irrigation	70	70	0	Watercourse
SE1/4	18	26	03	2	WILKINSON WILLIAM H		YORKTON	Irrigation	56	56	0	Watercourse
SE1/4	23	26	03	2	BARTLETT ROBERT G		YORKTON	Irrigation	11	11	0	Watercourse
NE1/4	35	26	03	2	KYLE GEORGE		YORKTON	Irrigation	11	11	0	Watercourse
SE1/4	35	27	03	2	RIFFEL HARVEY G		YORKTON	Irrigation	26	77	51	Reservoir
NE1/4	19	28	03	2	BOYCHUK MYRNA		CANORA	Irrigation	9	9	0	Watercourse
NE1/4	28	29	03	2	KOROL EUGENE		CANORA	Irrigation	5	5	0	Watercourse
SE1/4	19	30	03	2	STANKEWICH PAUL F		CANORA	Irrigation	10	10	0	Watercourse
NW1/4	25	31	03	2	TARASOFF BRENT		CANORA	Irrigation	4	4	0	Watercourse
NE1/4	31	32	03	2	STROCEN OREST		CANORA	Irrigation	52	52	0	Watercourse
NW1/4	32	32	03	2	APRIL ZORIA		CANORA	Irrigation	60	60	0	Watercourse
NE1/4	30	22	04	2	OLIJNYK MIKE		MELVILLE	Irrigation	8	8	0	
SW1/4	32	22	04	2	OLESKI DONALD W		MELVILLE	Irrigation	5	5	0	
SE1/4	08	24	04	2	STACHURA JOSEPH		OTTHAN	Irrigation	5	5	0	Watercourse
SE1/4	36	24	04	2	VERMETTE ELWYN		YORKTON	Irrigation	6	7	1	Reservoir
SW1/4	36	24	04	2	VERMETTE ELWYN E		YORKTON	Irrigation	7	8	1	Dugout
NE1/4	24	25	04	2	BITTNER IRVING		YORKTON	Irrigation	14	14	0	Watercourse
NE1/4	33	25	04	2	YORKTON	DEER PARK GOLF COURSE	YORKTON	Irrigation	122	122	0	Reservoir
SW1/4	03	26	04	2	NEUHOFER MARTIN		SHELLMOUTH	Irrigation	6	6	0	Reservoir
NE1/4	30	27	04	2	PATZER HAROLD		EBENEZER	Irrigation	0	0	0	Watercourse

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
NW1/4	12	29	04	2	BIGORAJ MARK		CANORA	Irrigation	6	6	0	Watercourse
SE1/4	23	33	04	2	TATARNIUK MYRON S		CANORA	Irrigation	46	46	0	Watercourse
SE1/4	25	33	04	2	CRYSTAL LAKE GOLF CLUB		INDIAN HEAD	Irrigation	42	42	0	Lake
NE1/4	04	35	04	2	FEDERIUK GEORGE M		STURGIS	Irrigation	175	175	0	Watercourse
NE1/4	04	35	04	2	FEDERIUK GEORGE M		STURGIS	Irrigation	91	91	0	Watercourse
NW1/4	16	23	05	2	CAPES SYDNEY J		MELVILLE	Irrigation	2	2	0	Dugout
SE1/4	28	24	05	2	TOTH MIKE		OTTHON	Irrigation	7	7	0	Watercourse
SW1/4	01	26	05	2	SITZ RICHARD		YORKTON	Irrigation	8	8	0	Watercourse
SW1/4	19	31	05	2	FOFONOFF CARL		BUCHANAN	Irrigation	5	5	0	Watercourse
SW1/4	13	32	05	2	CHARUK KENNETH M		FLIN FLON	Irrigation	0	0	0	Reservoir
NE1/4	02	24	06	2	SCHWITZER JOSEPH		MELVILLE	Irrigation	7	7	0	Watercourse
NW1/4	04	24	06	2	CARLSON MILTON		MELVILLE	Irrigation	12	12	0	Watercourse
SE1/4	06	24	06	2	WIKMAN KARL ERIC		MELVILLE	Irrigation	5	5	0	Watercourse
SW1/4	07	24	06	2	SWANBERG JOHN		MELVILLE	Irrigation	5	5	0	Watercourse
SE1/4	10	24	06	2	WASSILL PETER J		MELVILLE	Irrigation	4	4	0	
SE1/4	22	24	06	2	MAKAN MICHAEL		MELVILLE	Irrigation	6	6	0	
SE1/4	34	24	06	2	NAGY JIM		WILLOW BROOK	Irrigation	4	4	0	Watercourse
SW1/4	11	26	06	2	WATERSHED ASSOC	YORKTON CREEK	UNKNOWN	Irrigation	287	287	0	Watercourse
NW1/4	06	28	06	2	REEVES WILFRED		SPRINGSIDE	Irrigation	6	6	0	Watercourse
SW1/4	14	23	07	2	FEDUK MORRIS		MELVILLE	Irrigation	8	8	0	
SE1/4	29	23	07	2	FEDUK MORRIS		MELVILLE	Irrigation	21	21	0	Reservoir
SE1/4	02	24	07	2	JOHNSON ALFRED		MELVILLE	Irrigation	15	15	0	Watercourse
NW1/4	02	25	07	2	NAGY LOUIS		MELVILLE	Irrigation	1	1	0	
NE1/4	02	28	07	2	K & T BERRY FARM		THEODORE	Irrigation	4	5	1	Reservoir
NE1/4	22	29	07	2	KUZEK DENNIS		THEODORE	Irrigation	0	0	0	Reservoir
SE1/4	07	32	07	2	KRESAK RUDOLPH		INVERMAY	Irrigation	5	5	0	Watercourse
SE1/4	20	25	08	2	WILK REGINALD		MELVILLE	Irrigation	8	8	0	
NW1/4	06	26	08	2	FEDYK ANTON		HOMEFIELD	Irrigation	6	6	0	Watercourse
SE1/4	05	27	08	2	FLAMAN ROBERT J		JEDBURGH	Irrigation	6	6	0	Watercourse
SW1/4	07	27	08	2	FLAMAN ROBERT J		JEDBURGH	Irrigation	12	12	0	Watercourse
SW1/4	25	32	08	2	LAY FRANK GEORGE		RAMA	Irrigation	14	14	0	Watercourse
NW1/4	02	26	09	2	PFRA REGINA	GARRY PASTURE	REGINA	Irrigation	64	66	2	
SW1/4	04	26	09	2	PIHACH STEVE		HOMEFIELD	Irrigation	4	4	0	

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
SE1/4	12	27	09	2	FLAMAN ROBERT J		JEDBURGH	Irrigation	6	6	0	
NE1/4	23	27	10	2	LITWIN MATT D		PARKERVIEW	Irrigation	0	0	0	Watercourse
NE1/4	26	27	10	2	STADNYK PETER		PARKERVIEW	Irrigation	3	3	0	Watercourse
SE1/4	10	28	10	2	DYCK ARON		FOAM LAKE	Irrigation	6	6	0	Watercourse
NE1/4	14	28	10	2	FEDAK JOHN		PARKERVIEW	Irrigation	52	52	0	Watercourse
NW1/4	18	28	10	2	HNATIUK KEN E		FOAM LAKE	Irrigation	3	3	0	Watercourse
NE1/4	06	33	11	2	FOAM LAKE GOLF CLUB		FOAM LAKE	Irrigation	45	45	0	Lake
NW1/4	35	23	04	2	WATERSHED ASSOC YORKTON		UNKNOWN	Multiple	0	4333	4333	Watercourse
SW1/4	11	26	06	2	YORKTON		WILLOWBROOK	Multiple	0	4235	4235	Watercourse
NE1/4	19	28	06	2	SASK WATER	THEODORE DAM	MOOSE JAW	Multiple	0	617	617	Reservoir
SW1/4	03	30	32	1	KAMSACK		KAMSACK	Municipal	299	299	0	Reservoir
SW1/4	03	30	32	1	KAMSACK		KAMSACK	Municipal	269	417	148	Reservoir
NW1/4	27	30	32	1	COTE FIRST NATION		KAMSACK	Municipal	31	35	4	Reservoir
NW1/4	17	30	02	2	SLIDING HILLS RM OF		MIKADO	Municipal	20	22	2	Dugout
NE1/4	28	30	03	2	CANORA		CANORA	Municipal	30	30	0	Springs
NE1/4	28	30	03	2	CANORA		CANORA	Municipal	136	136	0	Wells
NE1/4	28	30	03	2	CANORA		CANORA	Municipal	0	0	0	Reservoir
NE1/4	28	30	03	2	CANORA		CANORA	Municipal	0	0	0	Reservoir
SW1/4	36	27	04	2	EBENEZER		EBENEZER	Municipal	17	18	1	Dugout
SE1/4	17	30	05	2	CANORA BEACH DEV. LTD.		CANORA	Municipal	1	1	0	Lake
SW1/4	06	23	06	2	MELVILLE		MELVILLE	Municipal	200	750	550	Reservoir
SW1/4	04	32	06	2	BUCHANAN		BUCHANAN	Municipal	17	19	2	Dugout
NE1/4	08	35	06	2	PREECEVILLE RM OF		PREECEVILLE	Municipal	1	3	2	Dugout
SE1/4	20	32	07	2	RAMA VILLAGE OF		RAMA	Municipal	25	40	15	Reservoir
NE1/4	28	23	08	2	STANLEY RM OF		MELVILLE	Municipal	19	22	3	Dugout
NE1/4	09	30	09	2	SHEHO		SHEHO	Municipal	1	13	12	Reservoir
SW1/4	01	32	11	2	FOAM LAKE RM OF		FOAM LAKE	Municipal	6	6	0	Springs
SE1/4	34	33	11	2	SASMAN RM OF		KUROKI	Municipal	19	31	12	Dugout
SW1/4	23	27	30	1	DUCKS UNLIMITED CANADA	NABE PROJECT	REGINA	Other	0	20	20	Lake
NW1/4	11	14	31	1	DUCKS UNLIMITED CANADA	MOOSOMIN PROJECT	REGINA	Other	0	5	5	Reservoir
SW1/4	13	17	31	1	DUCKS UNLIMITED CANADA	ROCANVILLE PROJECT	REGINA	Other	0	12	12	Reservoir
NW1/4	08	22	32	1	DUCKS UNLIMITED CANADA		REGINA	Other	0	463	463	Reservoir
SE1/4	30	30	01	2	MOROZOFF ALEX S		VEREGIN	Other	0	4	4	Reservoir

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
SE1/4	20	25	02	2	DUCKS UNLIMITED CANADA	FARRELL PROJECT	REGINA	Other	0	58	58	Reservoir
NE1/4	33	32	02	2	DUCKS UNLIMITED CANADA	SHUYA PROJECT	REGINA	Other	0	160	160	Reservoir
NW1/4	13	33	02	2	DUCKS UNLIMITED CANADA	HYAS SOUTH	REGINA	Other	0	342	342	Reservoir
SE1/4	22	24	03	2	DUCKS UNLIMITED CANADA	ROKEBY MARSH	REGINA	Other	0	1535	1535	Reservoir
NE1/4	28	24	03	2	DUCKS UNLIMITED CANADA	RUSSELL MARSH	REGINA	Other	0	149	149	Reservoir
SW1/4	14	25	03	2	DUCKS UNLIMITED CANADA	WALLACE MARSH	REGINA	Other	0	175	175	Reservoir
NW1/4	18	25	03	2	DUCKS UNLIMITED CANADA	KRAMER PROJECT	REGINA	Other	0	35	35	Reservoir
SW1/4	30	32	03	2	DUCKS UNLIMITED CANADA	FULTON MARSH	REGINA	Other	0	736	736	Lake
SE1/4	09	34	03	2	DUCKS UNLIMITED CANADA	STENEN PROJECT	REGINA	Other	0	190	190	Reservoir
NW1/4	10	34	03	2	DUCKS UNLIMITED CANADA	ZUBKO PROJECT	REGINA	Other	28	28	0	Reservoir
NE1/4	05	24	04	2	DUCKS UNLIMITED CANADA		REGINA	Other	0	58	58	Reservoir
NE1/4	11	24	04	2	DUCKS UNLIMITED CANADA	CRESCENT LAKE PROJECT.	REGINA	Other	0	0	0	Reservoir
SE1/4	28	24	04	2	DUCKS UNLIMITED CANADA	BUKLE PROJECT	REGINA	Other	0	0	0	Lake
NE1/4	03	26	04	2	DUCKS UNLIMITED CANADA	RAVINE ECOLOGICAL PRES.	REGINA	Other	0	74	74	Reservoir
NW1/4	29	27	04	2	DUCKS UNLIMITED CANADA	GUSE PROJECT	REGINA	Other	0	64	64	Reservoir
NE1/4	32	27	04	2	DUCKS UNLIMITED CANADA	EBENEZER PROJECT	REGINA	Other	0	65	65	Reservoir
SW1/4	33	27	04	2	DUCKS UNLIMITED CANADA	LEE PROJECT	REGINA	Other	0	25	25	Reservoir
NW1/4	22	28	04	2	DUCKS UNLIMITED CANADA	MCQUAT LAKE	REGINA	Other	0	354	354	Reservoir
SE1/4	25	33	04	2	DUCKS UNLIMITED CANADA	LILY POND PROJECT	REGINA	Other	0	15	15	Reservoir
NW1/4	35	25	05	2	DUCKS UNLIMITED CANADA	HAROLD UPLANDS	YORKTON	Other	0	0	0	Reservoir
NW1/4	23	26	05	2	DUCKS UNLIMITED CANADA	MCKEN PROJECT	REGINA	Other	0	59	59	Reservoir
SW1/4	27	27	05	2	DUCKS UNLIMITED CANADA	KLAUSE PROJECT	REGINA	Other	0	20	20	Reservoir
NE1/4	02	29	05	2	DUCKS UNLIMITED CANADA	HORSESHOE LAKE	REGINA	Other	0	1285	1285	Reservoir
SW1/4	11	26	06	2	YORKTON	WILLOW BROOK DIVERSION	YORKTON	Other	0	0	0	Watercourse
NW1/4	29	26	06	2	DUCKS UNLIMITED CANADA	SOREFOOT PROJECT	REGINA	Other	0	107	107	Reservoir
NW1/4	08	27	06	2	DUCKS UNLIMITED CANADA	SPRINGSIDE MARSH	REGINA	Other	0	114	114	Reservoir
SE1/4	28	27	06	2	DUCKS UNLIMITED CANADA	NEHRING PROJECT	REGINA	Other	0	17	17	Reservoir
NE1/4	22	31	06	2	DUCKS UNLIMITED CANADA	JOG PROJECT	REGINA	Other	0	135	135	Reservoir
NE1/4	28	31	06	2	DUCKS UNLIMITED CANADA	BUCHANAN PROJECT	REGINA	Other	0	135	135	Reservoir
SE1/4	12	27	07	2	DUCKS UNLIMITED CANADA	MCPHEE PROJECT	REGINA	Other	0	31	31	Reservoir
NW1/4	13	37	07	2	DUCKS UNLIMITED CANADA	YUBAN PROJECT	REGINA	Other	0	0	0	Reservoir
SW1/4	25	37	07	2	DUCKS UNLIMITED CANADA	YUBAN BASIN C&D PROJECT	REGINA	Other	0	0	0	Reservoir
SE1/4	35	37	07	2	DUCKS UNLIMITED CANADA	YUBAN BASIN	REGINA	Other	0	67	67	Reservoir

Saskatchewan - Active Surface Water Allocations

QTR	S	T	R	M	LICENSEE	PROJECT NAME	COMMUNITY	PURPOSE	ALLOC.	DIV.	LOSSES	SUPPLY
NW1/4	26	29	08	2	DUCKS UNLIMITED CANADA	INSINGER	REGINA	Other	0	6	6	Reservoir
NW1/4	26	29	08	2	DUCKS UNLIMITED CANADA	INSINGER PROJECT	REGINA	Other	0	227	227	Reservoir
SW1/4	24	30	09	2	DUCKS UNLIMITED CANADA		REGINA	Other	0	228	228	Reservoir
SE1/4	25	30	09	2	DUCKS UNLIMITED CANADA	EBELS MARSH PROJECT	REGINA	Other	0	353	353	Reservoir
SE1/4	18	31	09	2	DUCKS UNLIMITED CANADA	SAWCHUCK PROJECT	REGINA	Other	0	69	69	Lake
SE1/4	19	31	09	2	DUCKS UNLIMITED CANADA	HELENSKY PROJECT	REGINA	Other	0	96	96	Reservoir
SE1/4	35	31	09	2	INVERMAY RM OF	NEWBURN LAKE	INVERMAY	Other	0	0	0	Reservoir
NE1/4	16	32	09	2	SASK ENVIRONMENT	WAHAS MARSH	REGINA	Other	0	136	136	Reservoir
NW1/4	26	32	09	2	DUCKS UNLIMITED CANADA	FOGG PROJECT	REGINA	Other	0	290	290	Lake
NW1/4	26	32	09	2	DUCKS UNLIMITED CANADA	SALINE LAKE PROJECT	REGINA	Other	0	1240	1240	Reservoir
SW1/4	36	32	09	2	DUCKS UNLIMITED CANADA	STONEWALL PROJECT	REGINA	Other	0	790	790	Reservoir
NE1/4	23	31	10	2	DUCKS UNLIMITED CANADA	WETZEL PROJECT	REGINA	Other	0	274	274	Reservoir
SE1/4	34	31	10	2	DUCKS UNLIMITED CANADA	HONEYWICH PROJECT	REGINA	Other	0	50	50	Lake
SW1/4	36	31	10	2	DUCKS UNLIMITED CANADA	WOODY LAKE PROJECT	REGINA	Other	0	70	70	Lake
SW1/4	29	33	10	2	DUCKS UNLIMITED CANADA		REGINA	Other	0	800	800	Reservoir
NE1/4	02	34	11	2	DUCKS UNLIMITED CANADA	KUROKI PROJECT	REGINA	Other	0	0	0	Reservoir
SE1/4	07	34	11	2	SASK WILDLIFE FEDERATION		KUROKI	Other	0	25	25	Reservoir
SW1/4	22	34	11	2	DUCKS UNLIMITED CANADA	KUROKI DIVER	REGINA	Other	0	5	5	Reservoir
NE1/4	32	34	12	2	DUCKS UNLIMITED CANADA	ERICKSON PROJECT	REGINA	Other	0	17	17	Reservoir
SE1/4	24	27	14	2	DUCKS UNLIMITED CANADA	START PROJECT	REGINA	Other	0	1	1	Reservoir
NW1/4	25	27	14	2	DUCKS UNLIMITED CANADA	M. START PROJECT	REGINA	Other	0	1	1	Reservoir
NW1/4	33	33	14	2	DUCKS UNLIMITED CANADA	LITTLE QUILL RESTRICTION	REGINA	Other	0	1100	1100	Reservoir

Manitoba - Licenced and Pending Groundwater Allocations

License Number	Name	Original Application Date	Location	Purpose	Status	Expires	Maximum Annual Allocation (dam3)
92-124	Markowsky, Garnet William	08/15	NE7-26-29W	Agricultural	Approved License Issued		190
85-16	Manitoba Water Services Board	03/15	SE17-21-27W	Municipal	Approved License Issued	04/15	227
69-09	Manitoba Water Services Board	06/26	Inglis (36-22-28W)	Municipal	Approved License Issued	04/25	62
	The Rural Municipality of Silver Creek	01/15	SE-21-021-27W	Municipal	Waiting for Assessment of Application		

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam³)	ALLOC (dam³/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
BANGOR		Municipal	Urban Distribution	WELL #1	10	NE1/4	15	21	03	2	0.8	12.3	27-Nov-68	13-Jan-70	13-Dec-72
BIG SKY PORK INC		Industrial	Intensive Livestock	WELL #1 (STANDBY)	13	NW1/	23	35	09	2	1.5	1	29-Sep-97	30-Sep-98	30-Sep-98
BREDENBURY		Municipal	Urban Distribution	WELL #1	14	NW1/	35	22	01	2	5.7	61.5	22-Dec-66	03-Jun-70	21-Oct-71
BUCHANAN		Municipal	Urban Distribution	WELL #2B/95	03	SW1/	04	32	06	2	1.7	13.1	30-Oct-95	05-Feb-98	05-Feb-98
BUCHANAN		Municipal	Urban Distribution	WELL #4/89	06	SW1/	04	32	06	2	1.1	11.2	24-May-89	03-Oct-90	05-Feb-98
BUCHANAN		Municipal	Urban Distribution	WELL #1B/89	06	SW1/	04	32	06	2	1.1	11.2	08-Aug-90	03-Oct-90	05-Feb-98
BUCHANAN		Municipal	Urban Distribution	WELL #2/65	03	SW1/	04	32	06	2	2.3	49.2	11-Jun-68	22-Oct-74	03-Dec-74
											Total	84.7			
BUCHANAN RM OF		Municipal	Tankload	WELL #1		SE1/4	23	32	04	2	2.3	6.2	26-Nov-80	24-Sep-81	25-Feb-83
BUCHANAN RM OF		Municipal	Tankload	WELL #1		SE1/4	30	32	06	2	0.4	6.2	17-Apr-73	14-Sep-73	20-Apr-76
BUCHANAN RM OF		Municipal	Tankload	GOOD LAKE	14	NW1/	22	30	06	2	1.9	6.2	26-Nov-80	13-Aug-81	25-Feb-83
BUCHANAN RM OF		Municipal	Tankload	PW1-89	04	SW1/	32	33	04	2	6.1	2	06-Dec-89	06-Feb-91	07-Mar-97
BUCHANAN RM OF		Municipal	Tankload	WELL #1		NE1/4	33	33	05	2	1.1	6.2	26-Nov-80	24-Sep-81	25-Feb-83
BUCHANAN RM OF	HAMLET OF AMSTERDAM	Municipal	Urban Distribution	WELL #3/89	16	NE1/4	14	32	04	2	3.8	12	20-Dec-89	17-Oct-90	05-Mar-92
BUCHANAN RM OF	HAMLET OF CRYSTAL LAKE	Municipal	Urban Distribution	CRYSTAL LAKE		SE1/4	25	33	04	2	1.9	12.3	17-Apr-73	14-Sep-73	20-Apr-76
BUCHANAN RM OF	HAMLET OF TADMORE	Municipal	Urban Distribution	WELL #1		NE1/4	14	33	04	2	0.8	6.2	13-Sep-68	25-May-70	05-Dec-72
BUCHANAN RM OF	HAMLET OF TADMORE	Municipal	Urban Distribution	WELL #2		NE1/4	14	33	04	2	1.9	6.2	12-Aug-81	27-May-82	12-Aug-83
											Total	63.5			
CALDER		Municipal	Urban Distribution	WELL #1	05	SW1/	15	25	31	1	1.9	24.6	18-Jan-78	24-Jan-78	14-Jan-81
CHERRYDALE GOLF INC		Irrigation	Landscaping	WELL #1/89		SW1/	26	25	03	2	6.8	25.5	16-Mar-92	16-Mar-93	04-Jun-93
CHURCHBRIDGE		Municipal	Urban Distribution	WELL #3	07	SW1/	12	22	33	1	9.9	110	25-Oct-85	27-Mar-86	23-Apr-86
CHURCHBRIDGE		Municipal	Urban Distribution	WELL #4 (PW1/90)	01	SE1/4	32	21	32	1	18.9	200	22-Nov-90	26-Feb-91	21-Jul-97
											Total	310			
COTE RM OF	NAMLET OF RUNNYMEDE	Municipal	Tankload	RUNNYMEDE	03	SW1/	06	29	30	1	6.3	20	23-Jan-87	17-Feb-87	13-Jan-88

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam³)	ALLOC (dam³/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
CRESCENT CREEK POULTRY		Industrial	Intensive Livestock	WELL #2	13	NW1/	30	22	05	2	0.9	4.9	18-Jan-73	31-Jan-73	25-Feb-76
DAIRY PRODUCERS CO-OP		Industrial	Process Water	LANGENBURG NO. 1	04	SW1/	35	21	31	1	0.5	3.7	28-Jul-67	05-Jul-71	29-Jul-71
DAIRY PRODUCERS CO-OP		Industrial	Process Water	LANGENBURG NO. 2	04	SW1/	35	21	31	1	0.5	3.7	28-Jul-67	05-Jul-71	29-Jul-71
DAIRY PRODUCERS CO-OP		Industrial	Process Water	FOAM LAKE NO. 1	05	SW1/	32	30	11	2	0.3	3.7	28-Jul-67	27-May-71	29-Jul-71
DAIRY PRODUCERS CO-OP		Industrial	Process Water	MELVILLE #2	10	NE1/4	29	22	06	2	1.9	9.8	28-Jul-67	27-May-71	13-Jan-72
DAIRY PRODUCERS CO-OP		Industrial	Process Water	PREECEVILLE # 1	13	NW1/	28	34	05	2	1.5	9.8	28-Jul-67	27-May-71	29-Jul-71
DAIRY PRODUCERS CO-OP		Industrial	Process Water	MELVILLE #1	10	NE1/4	29	22	06	2	0.4	1.2	28-Jul-67	27-May-71	29-Jul-71
											Total	31.9			
DOME PETROLEUM LTD	MELVILLE STORAGE	Industrial	Cavern Washing	WELL #2	01	SE1/4	29	22	06	2	22.7	738	03-Nov-69	03-Dec-69	28-Jul-72
DOME PETROLEUM LTD	MELVILLE STORAGE	Industrial	Cavern Washing	WELL #1	04	SW1/	29	22	06	2	22.7	738	28-Sep-67	17-Feb-70	28-Jul-72
											Total	1476			
DUCK MOUNTAIN REGIONAL	DUCK MOUNTIAM PROV	Municipal	Recreation	WELL #1 SKI		SW1/	35	29	30	1	1.1	6.2	17-Jan-79	12-Feb-79	26-Mar-82
EBENEZER		Municipal	Urban Distribution	WELL #1	08	SE1/4	32	27	04	2	1.9	20.9	15-Oct-81	14-Oct-82	23-Sep-83
ENDEAVOUR		Municipal	Urban Distribution	WELL #2	08	SE1/4	09	37	05	2	7.6	30.7	28-Dec-77	20-Jan-78	22-Dec-80
ENDEAVOUR		Municipal	Urban Distribution	WELL #1	02	SE1/4	09	37	05	2	3.8	14.8	04-Jan-77	17-Jan-77	18-Sep-78
											Total	45.5			
F & B FEEDLOT LTD		Industrial	Intensive Livestock	EAST	13	NW1/	35	33	12	2	1.9	24.6	13-Jan-70	15-Jan-70	10-Apr-74
F & B FEEDLOT LTD		Industrial	Intensive Livestock	WEST	13	NW1/	35	33	12	2	1.9	24.6	13-Jan-70	15-Jan-70	10-Apr-74
											Total	49.2			
FENWOOD		Municipal	Urban Distribution	WELL #95-1	11	NW1/	27	23	08	2	0.4	5	09-Nov-94	16-Jan-95	13-Feb-95
FOAM LAKE		Municipal	Urban Distribution	WELL #1		SE1/4	18	31	11	2	5.7	24.6	18-Dec 67	14-Apr-72	07-Nov-72
FOAM LAKE		Municipal	Urban Distribution	WELL #2	14	NW1/	29	30	11	2	7.6	49.2	02-Nov-82	03-Nov-83	09-Mar-84
											Total	73.8			
FOAM LAKE RM OF	HAMLET OF TUFFNELL	Municipal	Urban Distribution	WELL #1	05	SW1/	33	30	10	2	0.5	17.2	21-Jun-68	25-May-70	22-Sep-72

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam^3)	ALLOC (dam^3/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
GARRY RM OF	HAMLET OF PARKERVIEW	Municipal	Community	HAMLET OF		NW1/	21	27	09	2	0.8	6.2	23-Mar-81	26-Mar-81	24-May-83
GERALD		Municipal	Urban Distribution	WELL #2	04	SW1/	34	19	31	1	2.3	24.6	01-Aug-67	03-Feb-77	03-Feb-77
GERALD		Municipal	Urban Distribution	WELL #3		SW1/	34	19	31	1	5.7	24.6	25-Mar-82	12-Apr-82	12-Mar-84
											Total	49.2			
HAZEL DELL RM OF		Municipal	Urban Distribution	HAZEL DELL	08	SE1/4	06	35	07	2	0.5	15	15-Jul-68	20-Mar-86	28-Oct-87
HAZEL DELL RM OF	HAMLET OF OKLA	Municipal	Tankload	OKLA COMMUNITY	16	NE1/4	17	35	08	2	3	15	21-Dec-87	04-Jan-88	26-Sep-89
											Total	30			
HYAS		Municipal	Urban Distribution	WELL #1	13	NW1/	05	34	02	2	3	49.2	03-Oct-74	10-Oct-74	24-Nov-82
INVERMAY		Municipal	Urban Distribution	WELL #3/89	14	NW1/	01	33	09	2	4.9	31	01-Feb-90	15-Feb-90	02-Nov-90
JEDBURGH		Municipal	Urban Distribution	WELL #2	01	SE1/4	01	27	08	2	0.8	9.8	22-Dec-75	05-Jan-76	07-Aug-79
KEYS RM OF	HAMLET OF CRYSTAL LAKE	Municipal	Urban Distribution	CRYSTAL LAKE		NW1/	19	33	03	2	2.5	18.5	02-Aug-76	17-Aug-76	23-May-84
LANGENBURG		Municipal	Urban Distribution	PW6/87	13	NW1/	26	21	31	1	10	66	26-Oct-87	18-Jan-88	08-Apr-92
LANGENBURG		Municipal	Urban Distribution	WELL #4	13	NW1/	26	21	31	1	15.2	153.8	31-Jan-83	24-Feb-83	20-Apr-83
LANGENBURG		Municipal	Urban Distribution	WELL #3	13	NW1/	26	21	31	1	4.2	49.2	26-Feb-76	23-Apr-76	20-Apr-83
											Total	269			
LANGENBURG RM OF		Municipal	Tankload	WELL #1	02	SE1/4	34	20	32	1	5.3	10	10-Feb-87	11-Feb-87	16-Oct-87
LANGENBURG RM OF	HAMLET OF MARCHWELL	Municipal	Urban Distribution	MARCHWELL #2	04	SW1/	15	21	30	1	3.8	14.7	21-Dec-81	07-Jan-82	05-Dec-83
											Total	24.7			
LESLIE BEACH	HAMLET OF LESLIE BEACH	Municipal	Urban Distribution	WELL #1	05	SW1/	07	33	11	2	1.9	6.2	21-Jun-79	03-Jul-79	10-Jun-82
LESLIE BEACH	HAMLET OF LESLIE BEACH	Municipal	Urban Distribution	WELL #2	05	SW1/	07	33	11	2	3.4	18.5	13-Oct-82	19-Oct-82	09-Mar-84
											Total	24.7			

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam³)	ALLOC (dam³/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
MACNUTT		Municipal	Urban Distribution	WELL #3		SW1/	22	24	30	1	2.3	22.1	14-Jun-74	08-Jul-74	01-Mar-82
MACNUTT		Municipal	Urban Distribution	WELL #1		NW1/	12	24	30	1	1.5	18.5	17-Feb-70	28-Nov-70	29-Oct-74
MACNUTT		Municipal	Urban Distribution	WELL #4		NW1/	12	24	30	1	1.1	25	22-Nov-84	26-Feb-85	20-Jan-86
											Total	65.6			
MARGO		Municipal	Urban Distribution	WELL #2	02	SE1/4	15	33	10	2	2.8	45	09-Feb-72	23-Dec-85	23-Dec-85
PELLY		Municipal	Urban Distribution	WELL #2	11	NW1/	27	33	32	1	5.7	30.7	31-May-76	15-Sep-76	08-Feb-78
PELLY		Municipal	Urban Distribution	WELL #3	11	NW1/	27	33	32	1	3	36	13-Dec-83	17-Jan-84	17-Jan-84
PELLY	WELL #1	Municipal		WELL #1		NW1/	27	33	32	1	1.9	30.8	05-Jul-68	04-Jun-70	17-Jan-84
											Total	97.5			
POTASH CORP SASK INC	ROCANVILLE MINE	Industrial	Mineral Recovery	WELBY #4 (PW4-79)	06	SW1/	09	18	30	1	25.8	245	17-Jul-68	04-Sep-69	20-Oct-89
POTASH CORP SASK INC	ROCANVILLE MINE	Industrial	Mineral Recovery	WELBY #3 (PW3-79)	06	SW1/	09	18	30	1	27	555	20-Mar-80	05-Nov-81	20-Oct-89
POTASH CORP SASK INC	ROCANVILLE MINE	Industrial	Mineral Recovery	WELBY #1 (PW1-68)	06	SW1/	09	18	30	1	25.8	582	17-Jul-68	04-Sep-68	20-Oct-89
											Total	1382			
PREECEVILLE		Municipal	Urban Distribution	WELL #1	13	NW1/	28	34	05	2	11.4	184.5	06-Feb-76	09-Mar-83	29-Jun-83
PREECEVILLE		Municipal	Urban Distribution	WELL #2	13	NW1/	26	34	05	2	18.9	184.5	10-Jun-81	09-Mar-83	29-Jun-83
											Total	369			
PREECEVILLE RM OF	HAMLET OF KETCHEN	Municipal	Urban Distribution	KETCHEN PW1/92	04	SW1/	23	35	06	2	4.2	6	09-Sep-92	13-Jun-94	13-Jun-94
PREECEVILLE RM OF	HINCHCLIFFE GROUP #1/89	Municipal	Tankload	HINCHCLIFFE		NE1/4	33	35	05	2	2.3	10	15-Feb-90	02-May-91	20-Sep-91
											Total	16			
RHEIN		Municipal	Urban Distribution	WELL #1	16	NE1/4	22	27	02	2	3	25	27-Oct-95	15-Jun-98	15-Jun-98
SALTCOATS		Municipal	Urban Distribution	WELL #3	14	NW1/	01	24	02	2	4.5	56	29-Nov-96	25-Nov-97	25-Nov-97
SALTCOATS		Municipal	Urban Distribution	WELL #2	14	NW1/	01	24	02	2	4.5	56	22-Jun-77	22-Jul-77	25-Nov-97
SALTCOATS		Municipal	Urban Distribution	WELL #1	03	SW1/	12	24	02	2	4.5	1	23-Jan-67	06-Jun-72	25-Nov-97
											Total	113			

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam³)	ALLOC (dam³/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	DW2-80PW-SOLIE	13	NW1/	27	30	30	1	0.4	3.7	26-Aug-80	24-Sep-80	16-Dec-82
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	M1-61PWP-INTERN	14	NW1/	35	30	30	1	2.3	6.2	10-Mar-78	30-Mar-78	18-Mar-81
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	W3-68PWM-INTERN	16	NE1/4	29	30	30	1	2.9	4.9	10-Mar-78	30-Mar-78	18-Mar-81
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	ST41-74PW-HAYTER	14	NW1/	35	30	30	1	1.5	6.2	10-Mar-78	30-Mar-78	18-Mar-81
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	DW34-80PW-SOLIE	14	NW1/	27	30	30	1	1.1	3.7	12-Feb-81	27-Feb-81	25-Apr-83
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	M1-61PWC-INTERN	14	NW1/	27	30	30	1	1.5	6.2	10-Mar-78	30-Mar-78	18-Mar-81
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	DW37-80PW-SOLIE	01	SE1/4	34	30	30	1	5.7	43.1	21-Feb-81	27-Feb-81	25-Apr-83
SASK ENVIRONMENT &	DUCK MOUNTAIN PROV	Municipal	Recreation	ST4-73PW-HALL	14	NW1/	27	30	30	1	1.9	6.2	10-Mar-78	30-Mar-78	18-Mar-81
											Total	80.2			
SASK ENVIRONMENT &	FOAM LAKE CAMPSITE	Municipal	Recreation	W2-72PW-OLSON E	13	NW1/	29	30	11	2	0.4	2.5	15-Feb-78	24-Feb-78	12-Feb-81
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	C3-64PW-HAYTER	04	SW1/	16	29	05	2	0.2	2.5	09-May-78	16-May-78	17-Nov-81
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	F19-68PW-OLSON	09	NE1/4	17	29	05	2	1.4	6.2	09-May-78	16-May-78	17-Nov-81
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	DW7-78PW-SOLIE	01	SE1/4	17	29	05	2	0.2	2.5	06-Feb-79	15-Feb-79	04-Jul-82
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	DW1-80PW-B&D	01	SE1/4	17	29	05	2	0.4	2.5	06-Feb-79	15-Feb-79	04-Jul-82
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	W20-73PW-OLSON	13	NW1/	09	29	05	2	0.4	3.7	15-Feb-78	24-Feb-78	16-Jan-81
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	F18-68PW-OLSON	09	NE1/4	17	29	05	2	1.4	6.2	09-May-78	16-May-78	17-Nov-81
SASK ENVIRONMENT &	GOODSPIRIT LAKE PROV	Municipal	Recreation	F1-65PW-HALL	01	SE1/4	17	29	05	2	0.4	2.5	09-May-78	16-May-78	17-Nov-81
											Total	26.1			
SASMAN RM OF	HAMLET OF KYLEMORE	Municipal	Community	KYLEMORE		NE1/4	09	34	12	2	0.5	7.4	02-Feb-73	12-Feb-73	16-Mar-76
SHEHO		Municipal	Urban Distribution	WELL #3		NE1/4	09	30	09	2	3	36.9	02-Sep-82	08-Sep-82	22-Feb-84
SHEHO		Municipal	Urban Distribution	WELL #2		NE1/4	09	30	09	2	3.8	43.1	14-Sep-76	05-Oct-76	20-Jun-78
											Total	80			
SLIDING HILLS RM OF		Municipal	Tankload	WELL #1		SE1/4	07	30	01	2	1.5	12.3	20-Jun-79	26-Jun-80	10-Jun-82
SPRINGSIDE		Municipal	Urban Distribution	WELL #1	02	SE1/4	23	27	06	2	1.4	43.1	25-Jan-67	29-Jul-70	06-Jul-72
SPRINGSIDE		Municipal	Urban Distribution	WELL #1	14	NW1/	11	27	06	2	5.7	67.7	03-Aug-78	02-Oct-80	26-Nov-82
											Total	110.8			

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam^3)	ALLOC (dam^3/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
SPY HILL		Municipal	Urban Distribution	WELL #1	08	SE1/4	12	19	31	1	3.8	49.2	09-Apr-68	25-Aug-71	07-Sep-72
SPY HILL RM OF		Municipal	Tankload	WELL #4	16	NE1/4	22	19	31	1	3.8	2	27-Sep-95	15-Apr-97	15-Apr-97
SPY HILL RM OF		Municipal	Tankload	SPY HILL	16	NE1/4	22	19	31	1	2.3	20	19-Mar-84	04-Apr-84	16-Jun-88
											Total	22			
STENEN		Municipal	Urban Distribution	WELL #2	01	SE1/4	04	34	03	2	3	37	29-Aug-85	29-Nov-85	02-Oct-86
STENEN	WELL #1	Municipal		WELL #1		SE1/4	04	34	03	2	1.9	36.9	21-Feb-69	18-Aug-70	15-Aug-89
											Total	73.9			
STORNOWAY		Municipal	Community	WELL #1	09	NE1/4	35	26	01	2	0.6	2	18-Dec-95	07-Oct-96	07-Oct-96
STURGIS		Municipal	Urban Distribution	WELL #1	04	SW1/	29	34	04	2	4.5	92.3	05-Jun-67	29-May-70	09-Dec-71
STURGIS		Municipal	Urban Distribution	WELL #2	04	SW1/	29	34	04	2	7.6	123	19-Jul-79	26-Jul-79	10-Jun-82
											Total	215.3			
THEODORE		Municipal	Urban Distribution	WELL #2	15	NE1/4	13	28	07	2	5.3	30.7	11-Dec-72	14-Dec-72	14-Oct-75
THEODORE		Municipal	Urban Distribution	WELL #3	15	NE1/4	13	28	07	2	6.1	55.4	10-Jul-80	18-Aug-80	25-Apr-84
											Total	86.1			
TOGO		Municipal	Urban Distribution	WELL #2	14	NW1/	01	28	30	1	1.1	30.7	22-Jul-80	14-Aug-80	08-Nov-82
TOGO		Municipal	Urban Distribution	WELL #1	14	NW1/	01	28	30	1	1.5	33.2	26-Jun-67	15-Dec-70	15-Dec-71
											Total	63.9			
TRANSGAS LIMITED	MELVILLE STORAGE	Industrial	Cavern Washing	BREWER 12-15	12	NW1/	15	23	06	2	18.9	463	25-Jun-62	03-Feb-70	15-Jun-94
VEREGIN		Municipal	Urban Distribution	WELL #3	04	SW1/	08	30	01	2	0.8	25	11-Mar-88	01-Mar-85	01-Mar-85
WILLOWBROOK		Municipal	Urban Distribution	WELL #1	12	NW1/	33	25	06	2	1.1	6.2	17-Dec-70	06-May-71	24-Feb-75
WILLOWBROOK		Municipal	Urban Distribution	WELL #2	12	NW1/	33	25	06	2	1.1	8.6	17-Dec-70	06-May-71	24-Feb-75
											Total	14.8			
WROXTON		Municipal	Urban Distribution	WELL #1	13	NW1/	03	26	32	1	2.3	12.3	20-Nov-78	29-Nov-78	09-Mar-82

Saskatchewan - Licenced Groundwater Allocations

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam^3)	ALLOC (dam^3/y)	DATE APPLIED	DATE CONSTR.	DATE APPROVED
YORK LAKE REGIONAL PARK		Municipal	Recreation	WELL #1	14	NW1/	15	25	04	2	3.4	6.2	24-Dec-70	12-Jan-71	04-May-76
YORKTON		Municipal	Urban Distribution	WELL #4	04	SW1/	03	26	04	2	27	308	08-Aug-68	15-Dec-75	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #8	01	SE1/4	03	25	04	2	57	1110	10-Mar-69	11-Jun-69	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #7	04	SW1/	04	26	04	2	23	493	21-Apr-67	15-May-67	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #3	11	NW1/	35	25	04	2	5	123	08-Aug-68	15-Dec-75	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #6	08	SE1/4	32	25	04	2	30	493	08-Aug-68	18-Feb-76	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #2	01	SE1/4	35	25	04	2	30	136	08-Aug-68	15-Dec-75	13-Jan-86
YORKTON		Municipal	Urban Distribution	WELL #1A	02	SE1/4	35	25	04	2	30	185	08-Aug-68	15-Dec-75	13-Jan-86
											Total	2848			
YORKTON	HOPKIN'S LAKE	Other	Recreation	HOPKIN'S LAKE	15	NE1/4	03	26	04	2	15	123	07-Jul-70	06-Aug-70	13-Jan-88

Saskatchewan - Applications for Groundwater Use Yet to Receive Approval

CLIENT	PROJECT NAME	PURPOSE	TYPE	WELL ID	LSD	QTR	S	T	R	M	DIV (dam³)	ALLOC (dam³/y)
BIG SKY FARMS INC		Industrial	Intensive Livestock	WELL #1	07	SE1/	27	35	06	2	19-Oct-98	- -
BIG SKY PORK INC		Industrial	Intensive Livestock	WELL #1	13	NW1/	03	35	09	2	22-Aug-97	- -
BUCHANAN RM OF		Municipal	Tankload			NW1/	22	30	06	2	16-Jan-92	- -
CHORNEY BEACH RESORT VILLAGE		Municipal	Urban Distribution	WELL #1/94	13	NW1/	06	33	11	2	01-Feb-95	- -
CHORNEY GORDON		Municipal	Urban Distribution	WELL #1	14	NW1/	06	33	11	2	19-Feb-99	- -
DUCK MOUNTAIN REGIONAL PARK	DUCK MOUNTAIN SKI HILL	Multi-	Recreation	DM1-94	11	NW1/	35	29	30	1	10-Jun-97	- -
FLAMINGO MOBILE COURT		Municipal	Urban Distribution	WELL #1	16	NE1/	20	25	04	2	24-Feb-83	20-Jun-84
FLAMINGO MOBILE COURT		Municipal	Urban Distribution	WELL #2	16	NE1/	20	25	04	2	24-Feb-83	20-Jun-84
FOAM LAKE RM OF	HAMLET OF TUFFNELL	Municipal	Urban Distribution	WELL #3	05	SW1/	33	30	10	2	17-Sep-91	- -
GOOD LAKE RM OF		Municipal	Tankload	WELL #1/82		SW1/	13	29	04	2	07-Oct-92	- -
HYAS		Multi-		HYAS GROUP PROJECT		SW1/	03	34	03	2	28-Aug-95	- -
INSINGER		Municipal	Urban Distribution	WELL #2	07	SE1/	21	29	08	2	18-Mar-98	- -
INSINGER		Municipal	Urban Distribution	WELL #1	07	SE1/	21	29	08	2	24-Mar-82	- -
INVERMAY		Municipal	Urban Distribution	WELL #4	14	NW1/	01	33	09	2	08-Aug-95	- -
PREECEVILLE RM OF	HAMLET OF LADY LAKE	Municipal	Tankload	LADY LAKE GROUP WELL	13	NW1/	23	35	05	2	22-Sep-83	29-Sep-83
PREECEVILLE RM OF	NORTH PRAIRIE GROUP #1/89	Municipal	Tankload	NORTH PRAIRIE GROUP		NE1/	08	38	06	2	18-Sep-89	02-May-91
PREECEVILLE SPORTS GROUND COMMITTEE		Municipal	Recreation	WELL #1		NW1/	28	34	05	2	08-Jun-[illegible]	- -
SALTCOATS RM OF		Municipal	Tankload	WELL #1/90		NE1/	13	24	03	2	21-Dec-95	- -
SASK ENVIRONMENT & RESOURCE MANAGEMENT	DUCK MOUNTAIN PR. PARK	Municipal	Recreation	PW1-86	15	NE1/	27	30	30	1	28-May-89	01-Jun-89
SASK ENVIRONMENT & RESOURCE MANAGEMENT	GOODSPIRIT LAKE PR. PARK	Municipal	Recreation	MR4-83PW-B&D	02	SE1/	17	29	05	2	21-Dec-83	09-Jan-84
SASK ENVIRONMENT & RESOURCE MANAGEMENT	MELVILLE MAINTENANCE CPD	Municipal	Commercial Facility	MR3-83PW-B & D	06	SW1/	31	22	06	2	21-Dec-83	09-Jan-84
SLIDING HILLS RM OF		Municipal	Tankload	WELL #3		SE1/	09	30	03	2	15-May-96	- -
SLIDING HILLS RM OF		Municipal	Tankload	WELL #5	12	NW1/	23	29	02	2	15-May-96	- -
SLIDING HILLS RM OF		Municipal	Tankload	WELL #2		SW1/	30	29	02	2	15-May-96	- -
SLIDING HILLS RM OF		Municipal	Tankload	WELL #4	12	NW1/	26	28	02	2	15-May-96	- -
SPY HILL		Municipal	Urban Distribution	WELL #2 (STANDBY)	08	SE1/	12	19	31	1	20-Nov-81	- -
VEREGIN		Municipal	Urban Distribution	WELL #5		SE1/	07	30	01	2	24-Aug-88	- -
VEREGIN		Municipal	Urban Distribution	WELL #4		SW1/	08	30	01	2	14-Mar-88	- -
YELLOWHEAD HOG VENTURES LTD PARTNERSHIP		Industrial	Intensive Livestock	NURSERY SITE 2	15	NE1/	29	28	08	2	03-Feb-99	- -
YORKTON		Municipal	Urban Distribution	WELL #11	14	NW1/	31	25	03	2	02-Nov-81	- -
YORKTON		Municipal	Urban Distribution	WELL #13	13	NW1/	28	25	04	2	02-Nov-81	- -
YORKTON		Municipal	Urban Distribution	WELL #12	13	NW1/	31	25	03	2	27-Mar-98	- -
YORKTON		Municipal	Urban Distribution	WELL #5	13	NW1/	28	25	04	2	08-Aug-68	18-Feb-76
YORKTON		Municipal	Urban Distribution	WELL #9	16	NE1/	34	24	04	2	17-Oct-79	- -
YORKTON		Municipal	Urban Distribution	WELL #10	01	SE1/	35	25	04	2	05-Apr-84	12-Apr-84

Appendix IV

Fish Species of the Upper Assiniboine River Basin

Fish Species of the Upper Assiniboine River Basin

(Note: Only native species and introduced species that have established self-sustaining populations are listed. Exotic species that rely on stocking to maintain a population are not included).

Scientific Name	Common Name	Abbreviation
Ambloplites rupestris	rock bass	RCBS
Ameiuris nebulosis	brown bullhead	BRBL
Catostomus commersoni	white sucker	WHSC
Carpiodes cyprinus	quillback	QUIL
Culaea inconstans	brook stickleback	BRST
Cyprinus carpio	common carp	CMCR
Esox lucius	northern pike	NRPK
Etheostoma exile	Iowa darter	IWDR
Etheostoma nigrum	johnny darter	JHDR
Hiodon tergisus	mooneye	MOON
Hybognathus hankinsoni	brassy minnow	BRMN
Ichthyomyzon castaneus	chestnut lamprey	CHLM
Lota lota	burbot	BURB
Luxilus cornutus	common shiner	CMSH
Margariscus margarita	pearl dace	PRDC
Moxostoma anisurum	silver redhorse	SLRD
Moxostoma macrolepidotum	shorthead redhorse	SHRD
Notropis atherinoides	emerald shiner	EMSH
Notropis dorsalis	bigmouth shiner	BGSH
Notropis heterolepis	blacknose shiner	BLSH
Notropis hudsonius	spottail shiner	SPSH
Notropis stramineus	sand shiner	SNSH
Noturus flavus	stonecat	STON
Perca flavescens	yellow perch	YLPR
Percina maculata	blackside darter	BLDR
Percopsis omiscomaycus	trout-perch	TRPR
Pimephales promelas	fathead minnow	FTMN
Pungitius pungitius	ninespine stickleback	NNST
Rhinichthys atratulus	blacknose dace	BLDC
Rhinichthys cataractae	longnose dace	LNDC
Semotilus atromaculatus	creek chub	CRCH
Stizestedion vitreum	walleye	WALL

Data sources:

McCulloch, B.R. and W.G. Franzin. 1996. Fishes of the Canadian portion of the Assiniboine River drainage. Can. Tech. Rep. Fish . Aquat. Sci. 2087:v + 62 p

Sentar Consultants Ltd. 1996. Inventory of fish occurrences and morphological characteristics of streams in the Assiniboine River drainage basin in Saskatchewan. Prepared for Dept. Fisheries and Oceans Canada.

SERM file information.

Appendix V

Collections of Fish Species from Streams

Fish Collected from the Upper Assiniboine River Basin

STREAM	SITE	LAT/LONG	PFL	DATE	INST	COLLECTOR	METHOD	SPECIES
Assiniboine River	4 ms ds Rockford		0360735SWXXXW2	09-Sep-97 11-Sep-97	SERM	R. Orr	S E	BLDR FTMN JHDR NRPK WHSC BRST IWDR
Assiniboine River	at Shellmouth	50°56'/101°29'		14-Aug-89	UMZ	B.R. McCulloch/J.D. Tyson	E	CMCR FTMN WHSC JHDR
Assiniboine River	at Hwy. 41	50°27'/101°18'		24-May-89	UMZ	B.R. McCulloch/J.D. Tyson	S	EMSH CMSH SNSH RCBS
Assiniboine River	at Conjuring Creek	50°48'/101°26'		07-May-89	UMZ	B.R. McCulloch/J.D. Tyson	E	FTMN CRCH WHSC STON JHDR BLDR
Assiniboine River	below Shellmouth Dam	50°58'/101°37'		24-May-89	UMZ	B.R.McCulloch/J.D. Tyson	E	QUIL BURB BLDR WALL
Assiniboine River	Hwy. 8	51°31'/101°50'		04-Jun-96	Sentar	B. Gloutney	G MT	NRPK WALL WHSC
Assinboine River	Hwy. 8	51°31'/101°50'		14-Aug-96	Sentar	B. Gloutney	G MT	NRPK WALL RCBS SHRD
Assiniboine River	Hwy. 754 (Sk)			14-Aug-89	UMZ	B.R. McCulloch/J.D. Tyson	E	CMSH LNDC WHSC SHRD JHDR BLDR
Assiniboine River	Kamsack			14-Aug-89	UMZ	B.R. McCulloch/J.D. Tyson	E	CMCR SNSH WHSC TRPR RCBS JHDR BLDR
Assiniboine River	Rockford		0370709NEXXXW2	09-Sep-97 11-Sep-97	SERM	R. Orr	S E	BLDR BRST JHDR NRPK WHSC FTMN IWDR BURB WALL
Assiniboine River	Shellmouth	50°56'/101°29'		16-Aug-90	UMZ	B.R. McCulloch/J.D. Tyson	E	EMSH SPSH SNSH FTMN CRCH STON JHDR
Assiniboine River	W. Roblin	51°15'/101°32'		08-Oct-55	ROM	J. J. Keleher		SNSH
Crooked Hill Creek	E. Mitchellview		0330518SWXXXW2	Jun-97	Sentar	B. Gloutney	E S MT	BRST
Crooked Hill Creek	E. Mitchellview	51°50'/102°39'		04-Jun-96	Sentar	B. Gloutney	MT	WHSC BRST FTMN SPSH BRMN
Crooked Hill Creek	E. Mitchellview	51°50'/102°39'		19-Aug-96	Sentar	B. Gloutney	MT	BRST FTMN EMSH
Crooked Hill Creek	N. Canora	51°40'/102°26'		03-Jun-96	Sentar	B. Gloutney	G MT	NRPK BRST FTMN
Crooked Hill Creek	N. Canora	51°40'/102°26'		19-Aug-96	Sentar	B. Gloutney	G MT	NRPK WHSC
Crooked Hill Creek	N. Canora		0310306NWXXXW2	Jun-97	Sentar	B. Gloutney	E S	FTMN BRST
Lake of the Prairies		51°17'/101°36'		1983		R.E. Jensen		MOON CMCR EMSH SPSH SLRD SHRD BRST RCBS IWDR
Lilian River	Hwy. 9		0350522NEXXXW2	09-Sep-97 11-Sep-97	SERM	R. Orr	S E	BRST FTMN JHDR WHSC BLDR IWDR
Shell River		50°58'/101°22'		08-Mar-53	ROM	B. Kooyman		FTMN

STREAM	SITE	LAT/LONG	PFL	DATE	INST	COLLECTOR	METHOD	SPECIES
Shell River		51°18'/101°18'		08-Oct-55	ROM	J.J. Keleher		SLRD
Shell River		51°17'/101°14'		08-Oct-55	ROM	J.J. Keleher		BLDC
Shell River		50°58'/101°24'		08-Oct-55	ROM	J.J. Keleher		IWDR
Shell River		50°59'/101°21'		07-May-89	UMZ	B.R. McCulloch/J.D. Tyson	E	LNDC WHSC SHRD JHDR BLDR
Shell River		51°35'/101°10'		08-Mar-53	ROM	B. Kooyman		BGSH
Shell River		50°58'/101°25'		08-Mar-53	ROM	B. Kooyman		CMSH BLDC LNDC CRCH TRPR JHDR BLDR
Shell River	E. of Roblin	51°12'/101°16'		14-Aug-89	UMZ	B.R. McCulloch/J.D. Tyson	E	CHLM CMSH BGSH FTMN BLDC LNDC WHSC SHRD BURB JHDR BLDR
Shell River	Hwy 594	51°28'/101°20'		18-Jul-72	UW	G.E.E. Moodie		CRCH BRST
Shell River	Hwy 83	50°58'/101°20'		07-May-89	UMZ	B.R. McCulloch/J.D. Tyson	E	EMSH BLDC LNDC CRCH WHSC SHRD JHDR BLDR
Shell River	Hwy 367	51°31'/101°19'		18-Jul-72	UW	G.E.E. Moodie		CHLM CMSH BLSH BLDC CRCH BRST BLDR
Spirit Creek	ds Patterson L.		0300625SEXXXW2	23-Jul-97	SERM	R. Orr	S	FTMN NRPK NNST SPSH BRST CMCR
Stony (trib) Creek		51°49'/102°11'		01-Jun-96	Sentar	B. Gloutney	MT E	BRST FTMN
Stony (trib) Creek		51°58'/102°22'		18-Aug-96	Sentar	B. Gloutney	MT	BRST FTMN
Stony (trib) Creek				Jun-97	Sentar	B. Gloutney	E S G	BRST FTMN
Stony (trib) Creek		51°49'/102°11'		17-Aug-96	Sentar	B. Gloutney	MT	BRST FTMN
Stony (trib) Creek		51°58'/102°22'		01-Jun-96	Sentar	B. Gloutney	MT G	BRST FTMN
Stony (trib) Creek	Hwy. 49	51°53'/102°17'		30-May-96	Sentar	B. Gloutney	MT E	BRST FTMN SPSH
Stony (trib) Creek	Hwy. 49	51°53'/102°17'		16-Aug-96	Sentar	B. Gloutney	MT E	BRST FTMN WHSC
Stony Creek	Mikado grid	51°49'/102°16'		16-Aug-96	Sentar	B. Gloutney	G MT DN	WHSC FTMN NRPK
Stony Creek	Mikado grid	51°49'/102°16'		30-May-96	Sentar	B. Gloutney	G MT	NRPK BRST FTMN
Stony Creek	Stenen		0330518SWXXXW2		Sentar	B. Gloutney	E S G MT	BRST FTMN
Stony (trib) Creek	Stenen	51°55'/102°23'		02-Jun-96	Sentar	B. Gloutney	MT	BRST FTMN
Stony (trib) Creek	Stenen	51°55'/102°23'		18-Aug-96	Sentar	B. Gloutney	MT	BRST FTMN WHSC
Wallace Creek			0302803NEXXXW2	23-Jul-97	SERM	R. Orr	S	BRST FTMN NRPK WHSC
Wallace Creek	W. Hamton		0280316NEXXXW2	23-Jul-97	SERM	R. Orr	S	BRST FTMN WHSC

STREAM	SITE	LAT/LONG	PFL	DATE	INST	COLLECTOR	METHOD	SPECIES
Whitesand River				1954	ROM	D.H. Edwards		CMSH BRBL
Whitesand River				1955	ROM	Atton/Johnson		CMSH
Whitesand River				1982		D. Sakal		EMSH JHDR
Whitesand River				1983		R.E. Jensen		CMSH FTMN WHSC BRST IWDR JHDR
Whitesand River				1962	ROM	D.H. Edwards		CHLM
Whitesand River				1982		J. Stock		PRDC
Whitesand River	Below Theodore Dam		0280619NEXXXW2	22-Jul-97	SERM	R. Orr	S	BLDR BRST FTMN JHDR NNST NRPK WALL WHSC YLPR IWDR
Whitesand River	Hwy. 9		0290402NEXXXW2	24-Jul-97	SERM	R. Orr	S	NRPK WHSC BLDR BRST FTMN JHDR TRPR
Whitesand River	Hwy. 47		0280601NWXXXW2	22-Jul-97	SERM	R. Orr	S	BLDR FTMN JHDR NRPK SPSH WHSC YLPR
Whitesand River	Mikado grid		0301222SWXXXW2	Jun-97	Sentar	B. Gloutney	S G	WHSC TRPR SNSH FTMN CMSH BLSH NRPK BURB SHRD
Whitesand River	Mikado Grid	51°40'102°13'		15-Aug-96	Sentar	B. Gloutney	G MT DN	NRPK WALL EMSH
Whitesand River	Mikado Grid	51°40'/102°13'		29-May-96	Sentar	B. Gloutney	G MT	NRPK
Whitesand River	SW Gorlitz		0280417SEXXXW2	24-Jul-97	SERM	R. Orr	S	FTMN NRPK JHDR YLPR
Yorkton Creek	1 mi. N. Mehan		0280301NEXXXW2	25-Jul-97	SERM	R. Orr	S	BRST FTMN WHSC
Yorkton Creek	SW Ebenezer		0280322NEXXXW2	25-Jul-97	SERM	R. Orr	S	FTMN JHDR NRPK WHSC
Yorkton Creek	SW Ebenezer		0270427SEXXXW2	24-Jul-97	SERM	R. Orr	S	BRST FTMN JHDR NRPK WHSC

Abbreviations:

Institute: SERM - Saskatchewan Environment and Resource Management
SENTAR - Sentar Consultants Ltd.
UMZ - University of Manitoba, Zoology Department
ROM - Royal Ontario Museum
UW - University of Winnipeg

Method: DN - Dip Net
E - Electroshocker
G - Gill Net
MT - Minnow Trap
S - Seine Net

Species: See Appendix IV

Appendix VI

Instream Flow Needs Estimates

Instream flow recommendations for the Upper Assiniboine River Basin

(All values given in cms)

Stream	MAF		Jan	Feb	Mar	Apr	CM	May	June	July	Aug	Sept	Oct	Nov	Dec
Assiniboine River at Sturgis - D1	2.051	Mean Flow	.081	.07	.208	8.964		7.672	3.456	1.668	.978	.573	.471	.313	.154
		IFN	.081	.07	.208	3.586	4.102	3.069	.82	.82	.82	.573	.471	.313	.154
Assiniboine River at Kamsack -D2	6.46	Mean Flow	.319	.274	.692	30.642		24.897	9.080	5.275	2.142	1.400	1.221	1.063	.509
		IFN	.319	.274	.692	12.257	12.920	9.959	3.632	2.584	2.142	1.400	1.221	1.063	.509
Fishing Lake Outlet - D3	.187	Mean Flow	0	0	.043	1.607		.502	.034	.053	.004	.001	.002	0	0
		IFN	-	-	-	-	-	-	-	-	-	-	-	-	-
Whitesand River near Sheho - D4	.262	Mean Flow	.002	.003	.025	1.345		.998	.391	.209	.062	.037	.035	.028	.008
		IFN	.002	.003	.025	.538	.538	.399	.156	.105	.062	.037	.035	.028	.008
Crooked Hill Creek near Canora - D5	.286	Mean Flow	0	0	.027	1.978		.971	.220	.160	.045	.021	.007	0	0
		IFN	0	0	.027	.791	.791	.388	.114	.114	.045	.021	.007	0	0

Stream	MAF		Jan	Feb	Mar	Apr	CM	May	June	July	Aug	Sept	Oct	Nov	Dec
Spirit Creek near - D6 Buchanan	.207	Mean Flow	0	0	.054	1.418		.644	.225	.100	.032	.009	.003	0	0
		IFN	0	0	.054	.567	.567	.258	.09	.083	.032	.009	.003	0	0
Shell River near Roblin - D7	2.244	Mean Flow	.561	.495	.674	5.325		7.159	4.012	2.983	1.343	1.062	1.353	1.227	.738
		IFN	.561	.495	.674	2.13	4.488	2.864	1.605	1.193	.898	.898	.898	.898	.738
Good Spirit Lake Outlet - D8	.809	Mean Flow	0	0	.210	5.536		2.516	.879	.391	.126	.036	.013	0	0
			-	-	-	-	-	-	-	-	-	-	-	-	-
Little Boggy Creek near Cote - D9	.357	Mean Flow	.007	.024	.204	1.592		.987	.471	.397	.211	.152	.147	.072	.021
		IFN	.007	.024	.143	.637	.714	.395	.188	.159	.143	.143	.143	.072	.021
Outlet Theodore Reservoir - D10	.666	Mean Flow	.006	.008	.063	3.522		2.504	.910	.531	.158	.092	.102	.070	.020
		IFN	.006	.008	.063	1.409	1.409	1.002	.364	.266	.158	.092	.102	.070	.020

Stream	MAF		Jan	Feb	Mar	Apr	CM	May	June	July	Aug	Sept	Oct	Nov	Dec
Whitesand River near Canora - D11	2.442	Mean Flow	.017	.024	.278	13.204		8.730	3.321	1.984	.644	.388	.410	.246	.061
		IFN	.017	.024	.278	5.282	5.282	3.492	1.328	.977	.644	.388	.410	.246	.061
Assiniboine River at Kamsack Weir - D12	3.455	Mean Flow	.238	.198	.358	15.026		13.729	5.098	2.825	1.349	.888	.714	.672	.364
		IFN	.238	.198	.358	6.01	6.910	5.492	2.039	1.382	1.349	.888	.714	.672	.364
Lake of the Prairies Outlet - D13	11.82	Mean Flow	1.716	1.563	3.021	47.178		41.075	17.077	11.607	5.208	3.677	3.693	3.655	2.398
		IFN	1.716	1.563	3.021	18.871	23.640	16.430	6.831	4.728	4.728	3.677	3.693	3.655	2.398
Shell River near Inglis - D14	3.049	Mean Flow	.764	.697	.988	7.779		9.169	5.346	4.023	1.869	1.465	1.832	1.688	.971
		IFN	.764	.697	.988	3.112	6.098	3.668	2.138	1.609	1.220	1.220	1.220	1.220	.971
Whitesand River above Yorkton Creek - D15	.835	Mean Flow	.008	.010	.079	4.416		3.140	1.141	.666	.198	.115	.128	.088	.025
		IFN	.008	.010	.079	1.766	1.766	1.256	.456	.334	.198	.115	.128	.088	.025

Stream	MAF		Jan	Feb	Mar	Apr	CM	May	June	July	Aug	Sept	Oct	Nov	Dec
Stony Creek near Kamsack - D16	.175	Mean Flow	0	0	.075	1.027		.571	.202	.175	.033	.004	.008	0	0
		IFN	0	0	.07	.411	.411	.228	.081	.07	.033	.004	.008	0	0
Cussed Creek at mouth - D17	.681	Mean Flow	.006	.008	.064	3.604		2.563	.932	.544	.161	.094	.105	.072	.021
		IFN	.006	.008	.064	1.442	1.442	1.025	.373	.272	.161	.094	.105	.072	.021
Yorkton Creek near Ebenezer - D18	.509	Mean Flow	0	.001	.105	2.954		1.429	.667	.455	.203	.132	.121	.041	.002
		IFN	0	.001	.105	1.182	1.182	.572	.267	.204	.203	.132	.121	.041	.002
Conjuring Creek near Russell - D19	.082	Mean Flow	0	.001	.030	.521		.241	.084	.067	.018	.015	.007	.001	0
		IFN	0	.001	.030	.208	.208	.096	.034	.033	.018	.015	.007	.001	0
Willow Brook at Willowbrook - D20	.106	Mean Flow	0	0	.007	.609		.395	.167	.071	.015	.007	.005	.002	0
		IFN	0	0	.007	.244	.244	.158	.067	.042	.015	.007	.005	.002	0

Stream	MAF		Jan	Feb	Mar	Apr	CM	May	June	July	Aug	Sept	Oct	Nov	Dec
Smith Creek near Marchwell - D22	.128	Mean Flow	0	.002	.056	.704		.409	.127	.108	.048	.031	.033	.012	.001
		IFN	0	.002	.051	.282	.282	.164	.051	.051	.048	.031	.033	.012	.001
Assiniboine River above Qu'Appelle River - D23	13.59	Mean flow	2.260	2.067	4.122	53.224		46.467	19.176	13.449	6.204	4.355	4.234	4.399	3.156
		IFN	2.260	2.067	4.122	21.290	27.180	18.587	7.670	5.436	5.436	4.355	4.234	4.394	3.156
Assiniboine River near Russell - D24	12.62	Mean flow	1.935	1.768	3.485	50.206		43.499	17.994	12.405	5.622	3.958	3.914	3.968	2.716
		IFN	1.935	1.768	3.485	20.082	25.240	17.400	7.198	5.048	5.048	3.958	3.914	3.968	2.716

MAF - Mean annual flow

Mean flow - Calculated mean natural flow

IFN - Instream flow recommendation
CM - Channel maintenance flow recommendation (flushing flow)

- •Channel maintenance flow recommendation is to be applied for a two week period during the month of highest flow. For most streams in the basin, this is April. For the Shell River, highest flows are in May therefore channel maintenance flows should occur in early May.
- •The channel maintenance flow recommendation is the same as for the remainder of April if the calculated channel maintenance flow (200% MAF) is less than the April IFN recommendation.

Appendix VII

Water Resources Management Model (WRMM)

Water Resources Management Model (WRMM)

The Water Resources Management Model (WRMM) for the Upper Assiniboine River Basin Study consists of a main model and two sub-models, the Yorkton South Complex sub-model and the Fishing Lake sub-model.. This configuration results from the fact that the two sub-models were developed prior to the Study. The Yorkton South Complex model was used to estimate natural flows for Yorkton Creek near Ebenezer and to provide the effect of water use and water regulation in the sub-basin on the rest of the Upper Assiniboine River Basin. Fishing Lake has not spilled over the period of record examined in the Study, therefore this sub-model has no effect on the Upper Assiniboine River Basin but was included simply for the sake of completeness.

Figure VII.1 shows the detailed schematic diagram for the main model and the relation of the two sub-models. The data needed to define and run the model includes:

Physical data: Includes such items as reservoir area/capacity curves, outflow rating curves, channel bank capacities, stage/discharge curves for weirs, etc. Physical data water obtained from reports and plans as necessary.

Water Supply: Water supply data originates from the natural flow data as described in the main report. Groundwater abstractions were simplified from recorded data and groundwater inflows were included where estimated in hydrology studies.

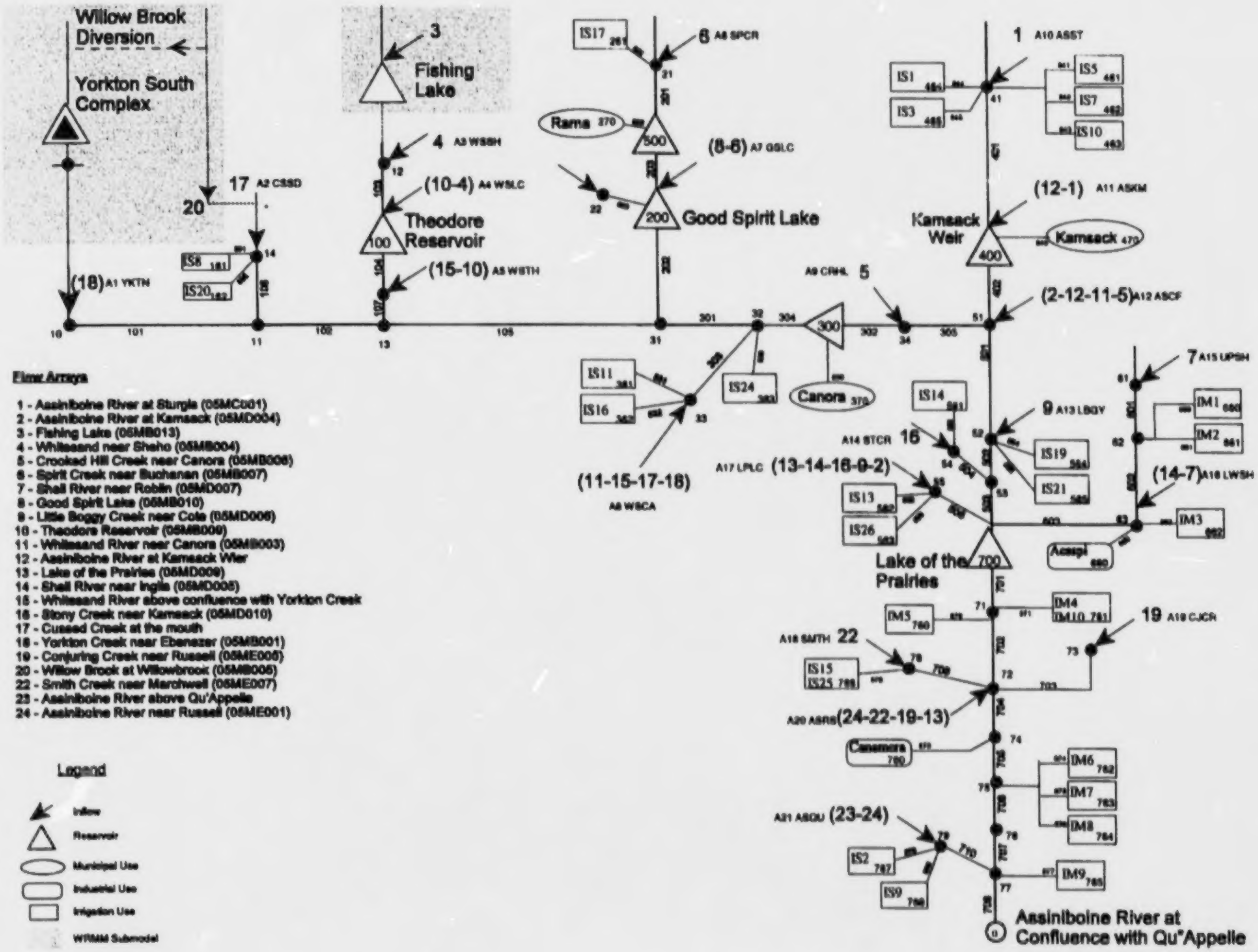
Water Uses: The major water uses as estimated in the main report were included. Municipal uses were the towns of Rama, Canora and Kamsack. Industrial users were Canamera Foods Ltd. and the Asessippi Ski Hill. Irrigation uses are shown in the figure with an identification number, cross referenced to the specific project in Tables VII.1 and VII.2.

Water Losses: The losses are primarily from evaporation. Net evaporation was estimated for each reservoir for each month of the simulation period. Gross evaporation estimates were calculated by the Prairie Farm Rehabilitation Administration using the methodology as described in Prairie Farm Rehabilitation Administration (1994) and the meteorological station at Yorkton. Precipitation estimates varied by reservoir and included data from climatological stations at Yorkton, Melville, Good Spirit Lake, Kamsack and Russell.

Operating Rules: The operating rules of the reservoirs and the general priority of uses within the Basin is described in the main report.

The Fishing Lake WRMM is described in detail in Sask Water (1997). The Yorkton South Project Sub-Model details are not published.

Figure VII.1 - Main Model Detailed Schematic Diagram


Willow Brook Diversion
Yorkton South Complex
20
17 A2 CSSD
(18) A1 YKTN
IS8 181
IS20 182
3
Fishing Lake
4 A3 WSSH
(10-4) A4 WSLC
100
Theodore Reservoir
(15-10) A5 WSTH
IS17 261
6 A6 SPCR
Rama 270
500
(8-6) A7 GSLC
200
Good Spirit Lake
IS11 361
IS16 362
(11-15-17-18)
A8 WSCA
IS24 363
300
Canora 370
A9 CRHL 5
1 A10 ASST
IS1 464
IS3 465
IS5 461
IS7 462
IS10 463
(12-1) A11 ASKM
Kamsack Weir
400
Kamsack 470
(2-12-11-5) A12 ASCF
IS14 561
9 A13 LBGY
IS19 564
IS21 565
A14 STCR 16
A17 LPLC (13-14-16-9-2)
IS13 562
IS26 563
Lake of the Prairies
700
7 A15 UPSH
IM1 660
IM2 661
(14-7) A16 LWSH
IM3 662
Acaspi 680
IM5 760
IM4
IM10 761
19 A19 CJCR
A18 SMTH 22
IS15
IS25 766
A20 ASRS (24-22-19-13)
Cenamora 780
IM6 762
IM7 763
IM8 764
A21 ASQU (23-24)
IS2 767
IS9 768
IM9 765
Assiniboine River at Confluence with Qu'Appelle
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Flow Arrays
1 - Assiniboine River at Sturgis (05MC001)
2 - Assiniboine River at Kamsack (05MD004)
3 - Fishing Lake (05MB013)
4 - Whitesand near Sheho (05MB004)
5 - Crooked Hill Creek near Canora (05MB006)
6 - Spirit Creek near Buchanan (05MB007)
7 - Shell River near Roblin (05MD007)
8 - Good Spirit Lake (05MB010)
9 - Little Boggy Creek near Cole (05MD006)
10 - Theodore Reservoir (05MB009)
11 - Whitesand River near Canora (05MB003)
12 - Assiniboine River at Kamsack Wier
13 - Lake of the Prairies (05MD009)
14 - Shell River near Inglis (05MD005)
15 - Whitesand River above confluence with Yorkton Creek
16 - Stony Creek near Kamsack (05MD010)
17 - Cussed Creek at the mouth
18 - Yorkton Creek near Ebenezer (05MB001)
19 - Conjuring Creek near Russell (05ME005)
20 - Willow Brook at Willowbrook (05MB005)
22 - Smith Creek near Marchwell (05ME007)
23 - Assiniboine River above Qu'Appelle
24 - Assiniboine River near Russell (05ME001)
Legend
Inflow
Reservoir
Municipal Use
Industrial Use
Irrigation Use
WRMM Submodel

Table VII.1 - Saskatchewan Model Irrigations Uses

Model I.D. Number	Location					Water Rights Number	Name	Diversion Volume (dam^3/y)
	QTR	SEC	TWP	RGE	M			
61	NE1/4	14	28	10	2	15491	FEDAK JOHN	52
62	SW1/4	07	27	08	2	13283	FLAMAN ROBERT J	12
261	SW1/4	25	32	08	2	15912	LAY FRANK GEORGE	14
361	SW1/4	15	27	02	2	14662	PROPP RICHARD C	34
362	SW1/4	19	28	02	2	15791	FILIPCHUK GLEN	15
363	SE1/4	19	30	03	2	15911	STANKEWICH PAUL F	10
461	NW1/4	32	32	03	2	14827	APRIL ZORIA	60
462	NE1/4	31	32	03	2	14810	STROCEN OREST	52
463	SE1/4	23	33	04	2	15058	TATARNIUK MYRON S	46
464	NE1/4	04	35	04	2	14691	FEDERIUK GEORGE M	91
465	NE1/4	04	35	04	2	14690	FEDERIUK GEORGE M	175
561	NW1/4	02	27	01	2	16200	WINTONYK LARRY J	27
562	SW1/4	05	28	30	1	13472	BURBACK VERNON	30
563	SE1/4	04	27	31	1	15054	DUBNYK ALBERT	10
564	NE1/4	19	28	31	1	15848	CHERKAS PAUL	13
565	NE1/4	18	28	31	1	16422	CHERKAS PAUL	12
767	SE1/4	05	19	30	1	13112	OLSON ALEXANDER E	161
768	NE1/4	03	19	30	1	13296	CLARKE HARRIS K	49
766A	SE1/4	08	22	31	1	16360	WINDERMERE ENTERPRIZES	18
766B	NE1/4	29	21	31	1	06343	WELKE CARL	10
YSP	NE1/4	35	26	03	2	11151	KYLE GEORGE	11
YSP	SE1/4	18	26	03	2	10631	WILKINSON WILLIAM H	56
YSP	SE1/4	23	26	03	2	12937	BARTLETT ROBERT G	11
YSP	NE1/4	24	25	04	2	15721	BITTNER IRVING	14
YSP	NE1/4	07	26	03	2	10662	BLOMMAERT WILFRED	70

Note: YSP = Yorkton South Project sub-model or Yorkton Creek near Ebenezer natural flow estimates.

Table VII.2 - Manitoba Model Irrigations Uses

Model I.D. Number	Location	License Number	Name	Maxium Annual Allocation (dam3)
660	SE27-27-28W	81-31	Case, R. W. & P. M.	185
661	S14-27-28W	62-57	Klimchuk, D. M.	49
662	SE-10-024-28W	78-4	Gaber, B. D., A. G. & D. A.	62
760	NW-17-022-	80-29	Nerbas, G. A. & K. R.	308
762	NE-15-020-29W	62-12	Clement, Harold F. & Rodney S.	222
763	-35-019-29W	62-18	Trinwood Farms Ltd.	175
764	NE-31-019-28W	87-89	Orsak, P. S.	17
765	-19-017-28W	89-50	Jean Blouin, Roland Blouin and Damien	247
761A	S34-22-29W	90-41	Neuhofer, Martin	12
761B	SW34-22-29W	84-40	Neuhofer, M.	12

Model Calibration Run

The calibration of the model subsisted more of an examination of l the model performance (i.e, how well the model simulated recorded flows in the system) than a true calibration where input parameters and internal routines are adjusted to more closely match simulated values with observed values.

The model was first configured and operated to reflect the current conditions as if they were present over the historical period. All major reservoirs, diversions and uses were included in addition to the current operating policies. It was then run to check its performance vs. key recorded flows and water levels, particularly Lake of the Prairies elevations. The primary period of focus was post 1969, as this is the time in which the major infrastructure (i.e., the reservoirs) were all in place.

Figure VII.1 shows the simulated and recorded Lake of the Prairies elevations. The simulated elevations reflect the recorded elevations reasonably well considering that the rules of operation in the model were much more simple than those actually practised. The model simulates drawdown to approximately the 425 m level every year, where in reality the reservoir was drawn down further prior to the mid to late 1980's and less later. This is because the operation of the reservoir was modified to a forecasted based operation , which the WRMM model does not simulate well without significant effort.

Since the operation of the Shellmouth Dam is the major factor affecting flows in the river below, the deficiency of the model calibration is also is apparent in the simulated flows for the Assiniboine River near Russell station as shown in Figure VII.2. Again, the simulated values, particulary after the late 1980's, show some differences from the recorded values. Regardless, general downstream conditions are mimicked and the model allows for the examination of downstream supply conditions based on the simplified operation of the reservoir. Plots of other flows in the, such as the Assiniboine River near Kamsack, generally showed no discernable differences from recorded flows thus are not included as figures.

This type of an approach is not an ideal calibration test, as with some effort the model could have been modified to reflect historical changes in infrastructure and use. However, this run represents a reasonable check of how well the model performs based on the data available. In light of the changes to infrastructure, operating policies and water use over time, it is thought that the model reflected the current system reasonably well for regional planning purposes, therefore no further work was conducted in an attempt to improve the model performance.

Figure VII.2 - Lake of the Prairies Simulated and Recorded Elevations

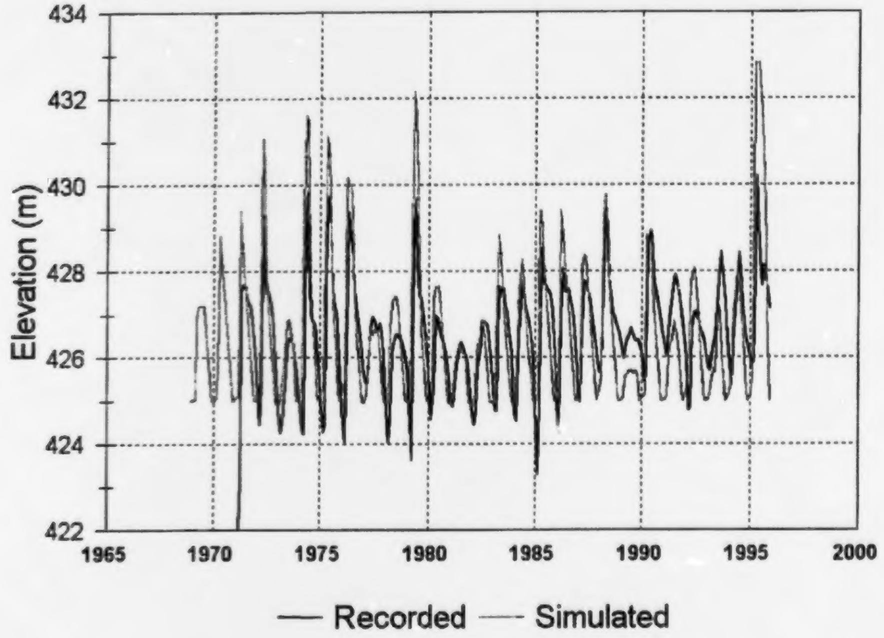
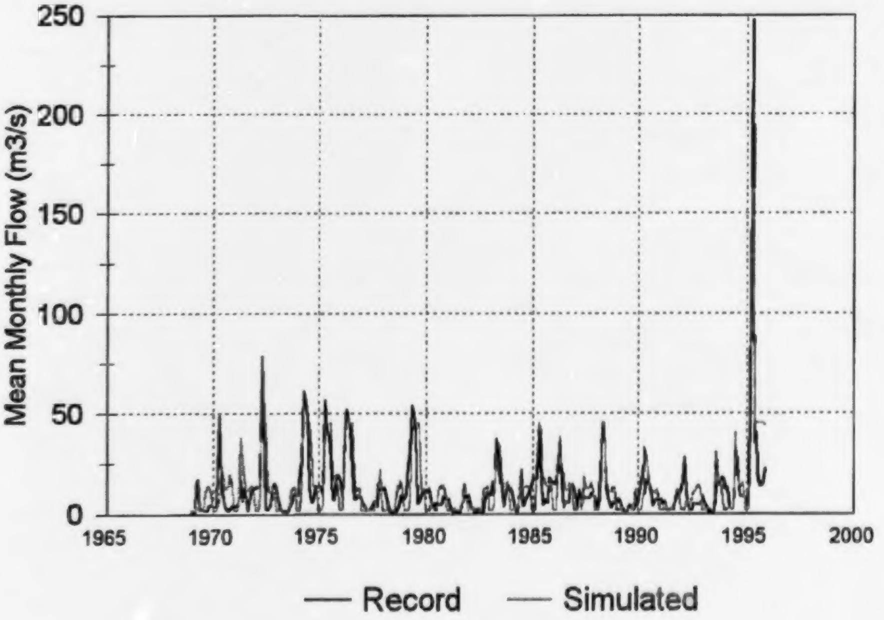


Figure VII.3 - Assiniboine River near Russell Simulated and Recorded Flows



References

Prairie Farm Rehabilitation Administration. 1994. Gross Evaporation for the 30-Year Period 1961-90 in the Canadian Prairies. Hydrology Report #133. Engineering and Sustainability Service, Regina, SK.

Sask Water. 1997. Fishing Lake Environmental Project Proposal. Environmental Management Branch, Moose Jaw, SK.

Appendix VIII

Shellmouth Dam and Reservoir Operation Guidelines

Shellmouth Dam and Reservoir Operating Guidelines

July 8, 1999

Mission Statement:

To operate the Shellmouth Dam and Reservoir as a multi-purpose facility to optimize the long-term social and economic benefits for all Manitobans.

Purpose:

The Shellmouth Dam and Reservoir was developed to relieve the flood threat and to ensure a sufficient water supply along the Assiniboine River in Manitoba. At the same time, other uses are made of the water controlled by the dam which result in a number of constraints that affect operating decisions. These uses include provision of municipal water supplies for the cities of Brandon and Portage la Prairie, cooling for thermal electric generation, irrigation, stockwatering, sewage effluent dilution and enhancement of recreation and fisheries both on the Shellmouth Reservoir and along the river between the reservoir and Winnipeg. Within the current operating regime, some discretionary variation is possible to meet the various interests at specific times. Since some of the operational demands are conflicting and some are compatible, the operation of the reservoir must be carried out in such a manner as to optimize the benefits and minimize conflicts to all those affected.

Operating Guidelines:

The generalized operating guidelines which have been developed to ensure that the reservoir can provide reasonable levels of both flood protection and water supply capability are indicated on Figure 1:

1. The reservoir is gradually lowered over the fall and winter period to provide flood storage capacity for the spring runoff which usually begins around the end of March. The winter drawdown target level is somewhat variable, dependent upon the spring inflow forecast. The original operating rule was to draw the reservoir down to a fixed winter target level of about 423.98 m. However, with improved probabilistic forecasting techniques the reservoir may now be lowered well below this point to increase flood storage capacity, or held well above this point to increase the likelihood that the available runoff will provide sufficient storage for water supply and recreational use during the summer period.

2. During spring runoff, the primary consideration is to control reservoir outflows to minimize downstream flooding. Excess inflows are stored in the reservoir until the water level nears the spillway crest elevation of 429.31 m . If inflow forecasts indicate that the spillway will be overtopped, outflows will be increased sooner, so as to minimize the eventual peak outflow. The intent is to minimize overbank flooding along the river below the dam and during flood periods to keep outflows to a value no greater than what the river flow would have been without the dam in place. An attempt is made to maintain outflows to a maximum of about 45.3 m^3/s to prevent localized flooding immediately downstream of the dam and to facilitate land drainage.

3. After spring runoff, reservoir levels are gradually lowered by conduit releases to a summer target level of about 427.48 m to optimize recreational and fishery conditions. The reservoir level may be held a few feet above this point to reduce the chances of water supply shortages when summer drought conditions are anticipated.

4. In the event of summer rainfall floods the available reservoir storage above the target summer level of 427.48 m is used to reduce downstream flow rates and minimize flooding. Outflows are increased if the level exceeds 428.24 m in order to reduce flooding of recreation facilities and to minimize the chance of overtopping the spillway.

5. During normal summer operation, the primary consideration is to make reservoir releases to meet water allocation commitments to downstream licensed users, for domestic users and to meet instream flow needs. Reservoir release rates are dependent upon the prevailing inflow rates, long-term inflow forecasts, downstream tributary flows and water demands. Reservoir release rates are varied throughout the year to meet a minimum target instream flow of 0.71 m^3/s immediately below the dam and 5.66 m^3/s at Headingley. Consideration must also be given to other factors such as travel time of Shellmouth Reservoir releases and maintaining an adequate reservoir level for recreational and fishery purposes.

Procedures:

General seasonal operation strategies for the reservoir are planned about three times per year - once in late fall for the winter drawdown period, in late winter in preparation for the impending spring runoff, and again in late spring for summer water supplies after the spring runoff period is over. These seasonal strategies are based largely on runoff forecasts and past experience.

While operation strategies set out the ideal operation scenario, the actual operations follow regular updates on hydrologic conditions and forecasts. These updates are done monthly from November to March, weekly or daily during spring runoff, and following major precipitation events.